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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G06F 15/20 | A1

(11) International Publication Number: WO 96/41278

(43) International Publication Date: 19 December 1996 (19.12.96)

(21) International Application Number: PCT/US96/08041

(22) International Filing Date: 29 May 1996 (29.05.96)

(30) Priority Data: 08/486,588 7 June 1995 (07.06.95) US

(71) Applicant: PANDA ENG., INC. [US/US]; 255 Brassy Court, Alpharetta, GA 30202 (US).

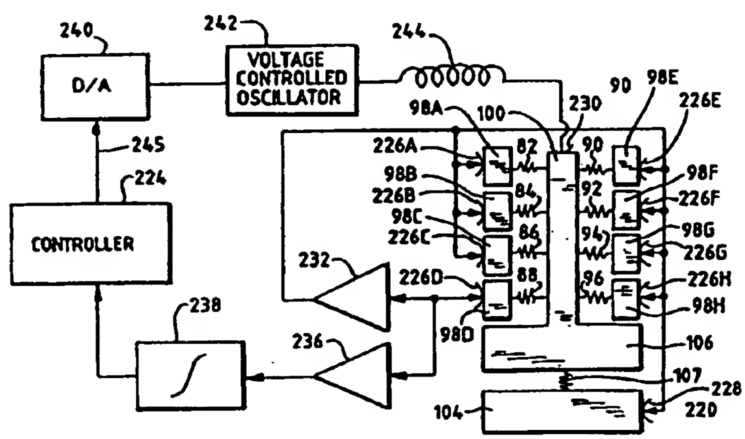
(72) Inventors: IRWIN, Kenneth, E., Jr.; 255 Brassy Court, Alpharetta, GA 30202 (US). STREETER, Gary, R.; 35 Williams Street, Andover, MA 01810 (US). DAIGLE, Steven, J.; Route 1, Box 100, Sunset, LA 70584 (US).

(74) Agent: PETERSON, Thomas, F.; Ladas & Parry, 224 S. Michigan Avenue, Chicago, IL 60604 (US).

(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: ELECTRONIC DOCUMENT VALIDATION MACHINE



(57) Abstract

The electronic verification machine (242) electronically couples with the circuit and applies an excitation signal such as an AC signal having a predetermined frequency through a read head (230) to the document (100) whereby the document includes a printed conductive material thereon. A sensor array (226A-H) in combination with detection circuit in the electronic verification machine (242) then generates a detection signal in response to the excitation signal which can both represent the location and the characteristics of the electrically printed material on the document. By storing the location of the conductive material on the document in a memory (224), the shape (238) of the conductive material can be determined. The electronic verification machine can also be used to stigmatize the document by applying a signal to the electronic circuits having sufficient strength to alter the electronic circuit.

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ELECTRONIC DOCUMENT VALIDATION MACHINE

Cross-Reference to Related Applications

This application is a continuation-part application of U.S. Patent Application Serial No. 08/268,908 filed June 22, 1994.

Field of the Invention

The invention relates to an electronic apparatus for obtaining information from a document, and more particularly, to an apparatus for determining the location and shape of a conductive area printed on a document such as a lottery ticket.

Background of the Invention

It is often desirable to obtain information from documents in addition to the human readable information printed on the surface of the document. For instance, documents of many types are susceptible to tampering, alteration and counterfeiting. Lottery tickets for probability games are an example of a document which is particularly susceptible to tampering: A probability game lottery ticket normally has play areas, each containing play indicia covered by an opaque material, for example a latex material. To play the game, an individual scratches off the latex covering a specified number of the play areas to reveal the play indicia underneath. The player then determines if the combination of revealed play indicia is a winner such as the play indicia are all the same symbol or add up to a winning number.

Part of the popularity of such probability games is derived from the fact that each and every ticket is a potential winner. If a player has lost, the player can scratch off the latex covering the remaining play areas and verify that at least one

winning combination is present. Consequently, this type of game is generally perceived by lottery players as being more legitimate than other types of instant lottery games.

The fact that every ticket is potentially a winner also invites players to tamper with the tickets. Because every ticket can win if the right play areas are selected, some players look for ways to determine the play indicia contained in every play area in order to identify the location of a winning combination. If the player can conceal the fact that he has seen the play indicia, the player subsequently can remove the latex covering from the play areas containing the winning combination and claim a prize.

One technique used to accomplish this result involves lifting the latex to look at the play indicia before gluing the latex back into place. Typically, probability game lottery tickets are validated by the visual observation of a human lottery agent. It can be difficult to visually detect this sort of tampering. Thus, probability game lottery tickets are particularly susceptible to fraudulent tampering and because no effective way of preventing or detecting such tampering has been developed, probability lottery games have not become commercially successful.

Similar problems exist with respect to pull-tab type lottery tickets. A pull-tab lottery ticket is made up of ticket stock with play indicia printed in certain locations and a upper layer having perforated pull-tabs covering the play indicia laminated to the ticket stock . Currently there is no convenient method for determining if the pull-tab ticket is a photocopy or if all of the pull-tabs have been removed.

A second threat to the integrity of a document is the intentional alteration of its contents. For example, an individual may try to alter the information on a driver's license, contract, test answer form, invoice or inventory form. Such an alteration may involve the changing of a number in the document by removing the original number and inserting a new number. In many cases alterations can be very difficult to detect, especially if there are no other copies of the document.

A third type of problem posed in the document security context involves counterfeiting. Rather than altering an existing document, the counterfeiter actually creates a document and attempts to pass it off as being genuine. Thus, paper currency, tickets, tags, and labels are often counterfeited and proffered as the real thing. The

magnitude of this problem has substantially increased with the advent of the color photo copier.

For example, the owner of a trademark might sell t-shirts bearing that trademark to increase the value of the shirt. In an attempt to thwart pirates, the trademark owner might also attach a identifying tag to the t-shirts. This makes it easier to determine whether a given t-shirt is genuine. In order to disguise the fact that t-shirts are counterfeits, a counterfeiter will reproduce not only the t-shirt's design, but also the tag. While being forced to create a similar looking tag will increase his costs, if the value of the trademark is sufficiently high, the counterfeiter will continue to attach a counterfeited tag.

There have been a number of techniques developed to improve the security of printed documents including the addition of magnetic materials to the document which are magnetically encoded with information that can be used to verify its authenticity. However, magnetically encoded information can in many instances be easily detected, read and altered and thus is not always suitable for verifying the integrity of a document.

Hence, it is desirable to provide an improved system for obtaining information from documents to verify or validate the documents and to thereby discourage tampering, alteration and counterfeiting.

Object and Summary of the Invention

It is therefore an object of the invention to provide a system for obtaining information from a document utilizing an electronic apparatus for determining the characteristics of an electronic circuit element printed on the document.

Another object of the invention is to provide a system for obtaining information from documents utilizing an electronic verification machine for receiving the documents and electronically coupling with a circuit element printed on the document such that a characteristic of the circuit element can be detected.

A further object of the invention is to provide an electronic validation machine for use with a document having a printed circuit element where the electronic validation

machine electronically couples with the circuit element and generates a detection signal representing a characteristic of the circuit element. The electronic validation machine applies an excitation signal to the circuit element printed on the document and incudes a detection circuit which generates the detection signal in response to the excitation signal. The excitation signal can be an AC signal having a predetermined frequency which can be coupled to the circuit element by a number of different methods including direct physical contact, capacitive or inductive coupling.

Still another object of the invention is to provide an electronic verification machine for use with a document having at least one area conductive material printed on the document surface where the verification machine includes an array of sensor plates, a circuit for applying an AC excitation signal to the document and a detection circuit connected to the sensor plates for detecting the presence of at least a portion of the conductive material. The detection circuit can also be used to generate a signal representing the shape of the conductive material on the ticket which in turn can be used to compare the shape to a predetermined shape stored in a memory.

Yet another object of the invention is to provide an electronic validation machine for use with lottery tickets having a scratch-off coating that includes a conductive material where the validation machine includes an excitation circuit for applying an excitation signal to the ticket and a validation circuit responsive to the excitation signal for determining the location of the scratch-off coating on the ticket.

A further object of the invention is to provide an electronic validation machine for use with pull-tab tickets where the upper portion of the ticket having the pull tabs also includes a layer of conductive ink such that the validation machine by applying an excitation signal to the ticket can determine if one or more of the pull-tabs have been removed. The excitation signal can also be used to determine if the ticket is a legitimate ticket.

An additional object of the invention is to provide an electronic verification machine that can determine the electrical signature of a circuit element printed on a document and apply a signal to the circuit element sufficient to stigmatize the document. This stigmatization can be achieved if for example the circuit element is a

fuse and the applied signal has sufficient power to blow this fuse. In addition to stigmatization, this technique can be used to store data on the document where a selected number of circuit elements or fuses are blown by the applied signal.

These objects are accomplished in the present invention by printing an electrical circuit onto the document. The circuits are printed in conductive or semiconductive ink using, for example, a gravure printing process. When the authenticity of the document is to be determined, an external verification machine is used to detect the presence and status of the circuit. Any attempted tampering or alteration of the printed document causes detectable changes in the characteristics of the circuit. Additionally, counterfeiting documents is made more difficult because a circuit acceptable to the external verification machine also must be counterfeited. The expense of determining how to print, and actually printing, an acceptable circuit generally outweighs any possible gain from the counterfeiting of documents. Therefore, the system reduces or eliminates counterfeiting of printed documents.

The secure document system is potentially useful for a wide variety of documents including, but not limited to, lottery tickets, especially probability game lottery tickets, currency, traveller's checks, credit cards, money cards, passports, stock and bond certificates, bank notes, driver's licenses, wills, coupons, rebates, contracts, food stamps, magnetic stripes, test answer forms, invoices, tickets, inventory forms, tags, labels and original art work.

Brief Description of the Drawings

FIG. 1 is a plan drawing of a probability lottery ticket having an electrical signature according to the invention;

FIG. 2 is a plan drawing of the partial electrical circuit that provides the card in FIG. 1 its electrical signature;

FIG. 3 is a schematic representation of a gravure printing press used to print the ticket in FIG. 1;

FIG. 4 is a plan drawing of the first layer printed on the ticket in FIG. 1;

FIG. 5 is a plan drawing of the second layer printed on the ticket in FIG. 1;

FIG. 6 is a plan drawing of the third layer printed on the ticket in FIG. 1;

FIG. 7 is a plan drawing of customized graphics printed on the first portion of the ticket in FIG. 1;

FIG. 8 is a plan drawing showing the placement of the play indicia, validation number, inventory control number, and bar code which are printed on the ticket in FIG. 1;

FIG. 9 is a plan drawing of the back of the ticket in FIG. 1;

FIG. 10 is a plan drawing of the fourth layer printed on the ticket in FIG. 1;

FIG. 11 is a plan drawing of the fifth and sixth layers printed on the ticket in FIG. 1;

FIG. 12 is a plan drawing of the seventh layer printed on the lottery ticket on FIG. 1;

FIG. 13 is a plan drawing of the eighth layer printed on the lottery ticket in FIG. 1;

FIG. 14 is a perspective view of an external verification machine according to the invention;

FIG. 15 is a perspective view of an alternative embodiment of an

external verification machine according to the invention;

FIG. 16 is a plan drawing of the user interface of the external verification machine in FIG. 14;

FIG. 17 is a block diagram of the major internal components of the external verification machine in FIG. 14;

FIG. 18 is a block diagram of the circuitry of the external verification machine in FIG. 14;

FIG. 19 is a plan drawing of the partial printed circuit used to determine the authenticity and integrity of the bar code of the ticket in FIG. 1;

FIG. 20 is a plan drawing of the partial printed circuit used to determine the authenticity and integrity of the play spot areas of the ticket in FIG. 1;

FIG. 21 is a plan drawing of another printed partial circuit which can be used to determine the authenticity and integrity of a probability lottery ticket;

FIG. 22 is a schematic circuit diagram of the completed circuit which is formed when the partial circuit in FIG. 20 is coupled to an external verification machine;

FIG. 23 is a plan drawing of a probability lottery ticket before the ticket is printed with yet another partial circuit which be used to determine the authenticity and integrity of the ticket;

FIG. 24 is a plan drawing of the release coat printed on the ticket in FIG. 23;

FIG. 25 is a plan drawing of the partial circuit used to determine the authenticity and integrity of the ticket in FIG. 23;

FIG. 26 is a plan drawing of the ticket in FIG. 23 in its final printed format;

FIG. 27 is a plan drawing of a second embodiment of the release coat printed on the ticket in FIG. 23;

FIG. 28 is a plan drawing of the circuit used to determine the authenticity and integrity of the ticket in FIG. 23;

FIG. 29 is a plan drawing of another circuit which can be used to

determine the authenticity and integrity of a probability game ticket;

FIG. 30 is a plan drawing of another circuit which can be used to determine the authenticity and integrity of a probability game ticket;

FIG. 31 is a plan drawing of four printed resistors having different resistances;

FIG. 32 is a plan drawing of a partial printed circuit which includes a calibration line;

FIG. 33 is a partial plan drawing illustrating a ticket inductively coupled to an external verification machine;

FIG. 34 is a partial plan drawing of a conductor which can be printed on a ticket to provide an RF antenna;

FIG. 35 is a partial schematic circuit diagram of circuit which measures thermal variations to determine the authenticity and integrity of a ticket;

FIG. 36 is a plan drawing of a lottery ticket having sixteen play spot areas;

FIG. 37 is a plan drawing of the ticket in FIG. 36 having the play spot areas removed to reveal the underlying play indicia;

FIG. 38 is a block diagram of a second embodiment of an external verification machine;

FIG. 39 is a partial sectioned side view of the external verification machine of FIG. 38 illustrating a document transport mechanism;

FIG. 40 is a block diagram of a portion of the circuitry of the external verification machine of FIG. 38;

FIG. 41 is a schematic diagram of a position sensor array and buffer circuit that can be used with the circuit of Fig. 39;

FIG. 42 is a perspective view of an alternative position sensor array that can be used with the external verification machine of FIG. 38;

FIG. 43 is a plan view of a first lottery ticket suitable for use with the external verification machine of FIG. 38;

FIG. 44 is a game signature map representing the location of a scratch-

off coating having conductive material on the lottery ticket of FIG. 43;

FIG. 45 is a data map representing the data out put of the external verification machine of FIG. 38 for the lottery ticket of FIG. 43;

FIG. 46 is an exploded perspective view of a pull-tab lottery ticket;

FIG. 47 is an illustrative top view of the pull-tab lottery ticket of FIG. 46 in conjunction with a signature map; and

FIG. 48 is an illustrative top view of the pull-tab lottery ticket of FIG. 46 positioned below an external verification machine sensor array.

Detailed Description of the Invention

I. General Overview

The present invention is directed to a method and to an interrelated group of devices for determining the authenticity and integrity of a document and includes printing a portion of an electrical circuit on the document or applying a material having electrical conductive properties on the document. "Document", as that term is used herein, is not limited to conventional printed papers but includes any type of flexible substrate as well as rigid substrates such as printed circuit boards. A document is authentic if it is not the product of counterfeiting. The integrity of a document relates to its current physical state as compared to its initial physical state and is affected by unauthorized modifications or attempted modifications of the document by, for example, subjecting the document to chemicals, heat, light, or pressure. The electrical characteristics of the printed circuit or the location of the conductive material provide the basis for determining both the authenticity and the integrity of the document. These characteristics can also be used to obtain data from the document.

A first method is to choose a predetermined, measurable electrical property, for example, a known resistance, that will serve as the electrical signature of the document. Next, at least a portion of an electrical circuit is printed on the document using conductive or semi-conductive inks. The electrical circuit is designed so that when the circuit is completed, the circuit will generate an electrical signature

that is substantially equal to a chosen predetermined electrical signature. Last, the circuit on the document is coupled to an external verification machine for determining the authenticity and integrity of the document by comparing the signal characteristics of the circuit on the document to the predetermined signature.

The external verification machine provides at least three functions. First, the external verification machine completes the circuit and provides a power source for exciting the circuit. Second, the external verification machine measures the resulting electrical signature of the document. And third, the external verification machine determines whether the measured electrical signature is substantially the same as the predetermined electrical signature. There are a number of ways in which the external verification machine can determine the authenticity and integrity of the document. The external verification machine can directly determine the authenticity and integrity of the document by using data directly available to the external verification machine. Alternatively, the external verification machine can indirectly determine the authenticity and integrity of a document by communicating the measured electrical signature to a remote computer which contains data related to the predetermined electrical signature for the document.

Determining the authenticity and integrity of the document is, in its simplest form, a logical progression. Generally, if an electrical signature can not be measured, the document is not authentic, is not in its original integral state, or both. On the other hand, if an electrical signature can be measured and the measured electrical signature is substantially the same as the predetermined electrical signature, the document can be assumed to be authentic and in its original integral state. If an electrical signature can be measured but is substantially different than the predetermined electrical signature, at the very least the document is not in its original integral state. This method will be explained in terms of a representative document which in this case is a probability game lottery ticket.

A second method is similar to the first method but involves the determination of the location of conductive materials on the document. This method will be explained in conjunction with the second embodiment of the external verification machine.

II. Probability Game Lottery Ticket Configuration.

Because this example of the preferred embodiment of the invention is that of a probability game lottery ticket, a brief overview of that application is helpful. A probability game lottery ticket typically includes a group of play areas or play spots, each containing play indicia covered by an opaque material, usually a latex material. A player can win a prize if he removes the latex from a predetermined combination or combinations of play spots which define one or more winning redemption values. Generally the player is instructed to rub off only a specified number of play spots. Thus, a game may require a player to rub off three play spots. In this case, if the player rubs off more than three play spots, the ticket is void and player automatically loses. If the play indicia under the removed play spots match one of the predetermined combination(s), the player is eligible to redeem the ticket for a prize. On the other hand if the removed play spots do not match one of the predetermined combination(s), the redemption value of the ticket will be zero.

FIG. 1 illustrates the final printed format of a probability game ticket 50 according to one embodiment of the invention. The ticket 50 includes a card substrate 52 which is generally divided into two portions. A first portion 54, the display portion, contains various types of printed information such as the name 56 of the probability game, information 58 related to the rules for playing the ticket, and customized art work 60. A second portion, the playing field portion 62, includes overprint areas 66, 68 and 76. The square overprint areas 66 define a group of play spot areas 72A-H of the ticket 50. As shown in FIG. 1, the overprint area of one play spot area 72A has been rubbed off the reveal the underlying play indicia 74. The play indicia 74 can take any on a variety of forms including, as shown here, a dollar value. The play indicia 74 can also be formed from letters or words alone, numbers alone, or symbols alone, or any combination of letters, numbers, or symbols. Although not illustrated, it is to be understood that play indicia similar to play indicia 74 underlie each of the play spot areas 72B-H.

The overprint area 76 defines the void-if-removed area of the ticket 50. A validation number 78, shown in FIG. 8, underlies the void-if-removed area defined by

the overprint area 76. The validation number 78 contains various types of security information including a portion that is usually algorithmically related to the pack number and ticket number for a particular ticket, such as the ticket 50. The pack number identifies the pack from which the ticket 50 originates. The ticket number relates to the position of the ticket 50 within the pack. In addition as will be explained below, the validation number 78 can also include information related to the electrical signature(s) of the ticket 50. The validation number 78 is useful for determining the authenticity and integrity of the ticket 50, as explained in greater detail below, in Section V.

A bar code 80 is also printed within the playing field portion 62 of the ticket 50. The bar code 80 can include information related to the validation number, the pack and ticket numbers for the ticket 50 and to the redemption values of various combinations of the play indicia 74 in each of the play spot areas 72A-H. The bar code 80 can also be used to store information about the value of the play indicia 74 on the ticket 50, as is explained in greater detail below, in Section V.

FIG 2. illustrates a partial electrical circuit 81 which is interposed between the overprint areas 64-68 and the play indicia 74 of the ticket 50 shown in Fig. 1. In the preferred embodiment, the circuit 81 includes eight resistor tracks 82-96 which are divided into two columns of four resistor tracks each. Each resistor track 82-96 underlies the overprint areas 68 shown in Fig. 1 which define each of the play spot areas 72A-H in FIG. 1. In addition, each resistor track 82-96 overlies a play indicia such as 74. Eight conductive or capacitive pick-up areas 98A-H are located around the periphery of the resistor tracks 82-96 and a central conductive track 100 is located between the two columns of resistor tracks 82-96. The central conductive track 100 is connected to a conductive I-track shown at 102 which includes a terminal conductive bar 104 and a second conductive bar 106 parallel to and spaced apart from the terminal conductive bar 104. A resistive track 107 connects the terminal conductive bar 104 to the second conductive bar 106. In the final printed format, such as that shown in FIG. 1, the terminal conductive bar 104 underlies the bar code 80.

Each resistor track 82-96 is electrically connected to the central

conductive track 100 and to one of the conductive areas 98A-H, for example, resistor track 82 is electrically connected to central conductive track 100 and to conductive area 98A. The conductive areas 98A-H and the central conductive track 100 are used to capacitively couple the ticket 50 to an external verification machine 108, such as that illustrated in FIG. 14. In the preferred embodiment, each conductive area 98A-H acts as a capacitor plate, the other capacitor plate being provided by the external verification machine 108. In addition, the central conductive track 100 also acts as a capacitor plate, the second capacitor plate being provided by the external verification machine 108. The capacitive coupling of the conductive areas 98A-H and the central conductive track 100 to the external verification machine 108 completes the printed circuit 81 and permits the external verification machine 108 to excite the circuit and to measure the electrical signature or signatures of ticket 50. Since the capacitive coupling of the conductive areas 98A-H and the central conductive track 100 to the external verification machine 108 permits the external verification machine 108 to measure the electrical signature(s) of ticket 50, areas 98A-H and track 100 are also known as capacitive pick-up areas because through these areas the external verification machine 108 "picks-up" the electrical signature of ticket 50.

Because each of the resistor tracks 82-96 is electrically connected to both the central conductive bar 100 and to one of the conductive areas 98A-H, each of the resistor tracks 82- 96 forms a complete circuit when the ticket 50 is coupled to the external verification device 108. Thus each of the resistor tracks 82-96 has its own electrical signature equal to the printed resistance of the resistor track. As shown in FIG. 2, each of the four resistor tracks in the two columns has the same resistance. Since each of the resistor tracks 82-96 is electrically connected to its associated conductive area 98A-H, the integrity of the eight circuits containing the eight resistor tracks 82-96 can be determined by reference to the specific conductive area 98A-H used to measure the electrical signature. Alternatively, each resistive track may have a unique resistance. For example, the resistor track 82 can have a resistance of 100 KΩ, the resistor track 84 can have a resistance of 300 KΩ, the resistor track 86 can have a resistance of 500 KΩ, and the resistor track 88 can have a resistance of 2700 KΩ.

Similarly, the resistor tracks 90-96 can have resistances of 100 KΩ, 300 KΩ, 500 KΩ, and 700 KΩ respectively. As is explained in greater detail in Sections III and IV.C.1., the magnitude of the resistance for a specific resistor track is a function of the type of ink used to print the resistor track, the length of the resistor track and the cross-sectional area, including the thickness, of the resistor track. Differences in the four resistances 82-88 or 90-96 in a given column of resistor tracks facilitate the determination of the authenticity and the integrity of the ticket 50 and more particularly can be used to determine which of the overprint areas 68 have been rubbed off.

Circuit 81, as shown in FIG. 2, is actually a composite of several layers used to print ticket 50. The following section describes in detail the sequence and relationship of the various layers used to print ticket 50.

III. Printing The Electrical Signature

In the preferred embodiment, the circuit 81 is printed onto the ticket 50 preferable via a gravure printing process. The gravure printing process allows for the widest range of ink and coating formulations. The gravure printing process, however, is not the only printing process that can be used to print the circuits. Gravure is only one type of intaglio printing process. Other types of intaglio printing processes can be used as well. In addition, the circuit 81 can be printed via screen printing, relief printing, planographic printing, letterpress and flexographic printing. In the preferred embodiment, the ticket 50 is printed on a paper substrate. Paper substrates are preferred because they offer good insulation and absorbency. Alternatively, the ticket 50 could be printed on a plastic or a metal, such as an aluminum foil, substrate. If a foil substrate is used, portions of the foil can serve as the main conductor for the ticket 50, while other portions of the ticket 50 are covered with an insulating layer.

FIG. 3 is a schematic diagram representing a gravure printing press 112 suitable for printing ticket 50. The press 112 has fifteen gravure printing stations 114-142 and one ink jet station 144. As is explained in more detail below, each of the press stations 114-142 prints one layer on the ticket 50 while the ink jet printer 144 prints the play indicia 74 and the bar code 80.

Station 114 prints a first layer or surface 146 which is shown in FIG. 4. The first layer 146 is printed with a conductive-carbon based ink and forms a part of the circuit 81 shown in FIG. 2. The first layer 146 includes two portions the first of which is an I-track 148. The I-track 148 includes the terminal conductive bar 104 and the resistive track 107 which form part of the I-track 102 illustrated in FIG. 2. A second conductive bar 150 of the I-track 148 underlies the second conductive bar 106 of the I-track 102 of FIG. 2. The second portion of the first layer 146 consists of a pair of rows of blocking cells 152. Each of the blocking cells 152 is positioned to underlie one of the play indicia 74 which are subsequently printed on the ticket 50.

The ink used to print the layer 146 should have a sheet resistivity below 2,700 Ω/□ preferably in the range of 1,000 Ω/□ to 1,300 Ω/□. In the ticket 50 shown in Figs. 1-13, the ink used to print the lower conductive layer 146 would most desirably have a sheet resistivity of 1,200 Ω/□. "Sheet resistivity" (ρs), as that term is used herein, is the bulk resistivity of the ink (ρ) divided by the thickness of the film of ink (t) printed on the ticket 50.

$$\rho s = \rho / t.$$

Sheet resistivity (ρs) will typically be expressed in terms of ohms/square (Ω/□). In practice, the sheet resistivity of an ink is determined by printing and measuring the resistance of a unit length and width.

The resistance (R) of a specific resistor in turn is a function of the bulk resistivity of the material and the dimensions of the resistor:

$$R = \rho(l/tw)$$

where ρ is the bulk resistivity of the material used to make the resistor, l is the length of the resistor, t is the thickness of the resistor and w is the width of the resistor. Substituting the previous equation for sheet resistivity into the equation for resistance yields the following:

$$R = \rho s(l/w)$$

Thus, the resistance of a resistor printed with a conducting or semi-conducting ink is a function of the sheet resistivity of the ink, the length of the printed resistor, and the width of the printed resistor. For example, the resistance of a printed resistor with an

ink having ρs = 100 Ω/□ which is 0.120 inches (0.3048 cm) long and 0.040 inches (0.1016 cm) wide would be:

$$R = \rho s(l/w) = 100\ \Omega/\square(0.0120/0.040) = 300\ \Omega.$$

The ink used to print the first layer 146 should also have very good adhesive properties so that the layer 146 adheres well to the ticket 50 and should have good abrasion resistance properties so that the layer 146 is not easily rubbed off the ticket 50. A preferred formulation for the ink used to print the first layer 146 is given in Table 1.

Table 1: Preferred Ink Formulation For Layer 1

material	wt %
Acrylic Resin	12-18%
Pentaerythritol ester of modified rosin	2-6%
Conductive carbon	14-20%
Polyamine amide/acidic ester dispersant	0.3-1.0%
2-ethyhexyl diphenyl phosphate plasticizer	2-5%
Anhydrous ethyl alcohol	20-30%
Normal Propyl acetate	23-33%
50/50 mixed solvent, normal propyl acetate and ethyl alcohol	5%
950 varnish	5%

The 950 varnish comprises 36.24% normal propyl acetate, 24.92% DM55 acrylic, 12.92% pentalyn 830, 17.92% nitro varnish, and 3% santicizer 141. The preferred formulation provides a film former, solvent based ink. Film formers are polymers capable of being plasticized to form a continuous and totally flexible ink. In the preferred formulation, the solvent evaporates from the printed surface during drying leaving a continuous, conductive dry ink film. Preferably, the conductive carbon will be about 2-20μ in size in this formulation.

The first layer 146 serves at least two purposes. First, the solid black

nature of the blocking cells 152 of the first layer 146 serves to prevent unauthorized detection of the play indicia 74, for example, by shining a bright light through the ticket 50. Second, the I-track 148 can be used to protect the bar code 80 against unauthorized modifications, by providing an electrical signature for the bar code 80 which can be measured by the external verification machine 108. It should be noted that in some cases, especially where the ticket 50 does not include the blocking cells 152, it may be desirable to print an opaque blocking layer between the substrate 52 and the play indicia 74.

Station 116 prints the second layer 156 which is shown in FIG. 5. The second layer 156 has two portions: an upper portion 156a and a lower portion 156b. The upper portion 156a overlies all of the blocking cells 152 of the first layer 146 shown in Fig. 4. The lower portion 156b overlies the terminal conductive bar 104 and the resistive track 107 of the I-track 148 of the first layer 146. The gap between the upper portion 156a and the lower portion 156b exposes the second conductive bar 150 of the I-track 148 of the first layer 146. The second layer 156 acts as a blocking layer to prevent the first layer 146 from obscuring observation of the play indicia 74 when the ticket 50 is played. A suitable formulation for the second blocking layer 156 is disclosed in U.S. Patent Application Serial No. 08/004,157 the entire disclosure of which is hereby incorporated by reference.

A third layer 158 is then printed by the printing station 118. The placement of the third layer 158 is essentially coincident with the second layer 156, as shown in FIG. 6. The third layer 158 also includes a upper portion 158a and a lower portion 158b separated by a gap which exposes the second conductive bar 150 of the I-track 148. The third layer 158 is a primer layer which provides a suitable surface for printing the play indicia 74. A suitable formulation for the third primer layer is disclosed in Walton, U.S. Patent No. 4,726,608.

Printing stations 120-126 provide the features printed on the display portion 54 of the ticket 50, as shown in FIG. 7. These printed features include the name 56 of the probability lottery game, information 58 related to the rules for playing the game, and customized art work 60. Because 4 different printing stations 120-126

are used to print these features, as many as four different colors of ink can be used to print process colors.

The ink jet printer 144 prints the play indicia 74 on a portion of the third layer 158, as shown in FIG. 8. In the preferred embodiment, there are two columns of play indicia 74, each of which contains four separate play indicia 74. The two rows of play indicia 74 are positioned so that each separate play indicia 74 overlies one of the blocking cells 152 of the first layer 146 shown in Fig. 4. The ink jet printer 144 also prints the inventory control number 70, the validation number 78, and the bar code 80 on the ticket 50. In the preferred embodiment, the inventory control number 70, the play indicia 74, the validation number 78, and the bar code 80 are printed with a water-based dye.

Printing station 128 prints the back 157 of the ticket 50 as shown in FIG. 9. The back 157 may include additional information 159 related to the rules for playing the ticket 50.

The print station 130 prints a fourth layer 160 on the ticket 50. The fourth layer 160 is indicated by the shaded portions in FIG. 10. The fourth layer covers the upper and lower portions 158a, 158b of the third layer 158 shown in Fig. 7, and also covers the play indicia 74, the inventory control number 70, the validation number 78, and the bar code 80. In the same manner as the second and third layers 156 and 158, the fourth layer does not cover the second conductive bar 150 of the I-track 148. The fourth layer 160 is a seal coat which protects the inventory control number 70, play indicia 74, the validation number 78, and the bar code 80 from abrasion and from liquids in which the play indicia 74, the validation number 78, and the bar code 80 are soluble. Suitable materials for this purpose include various polymer materials such as acrylics, polyester urethane, epoxy acrylate, and vinyl polymer. A suitable formulation for the third primer layer 158 of Fig. 6 is disclosed in Walton, U.S. Patent No. 4,726,608.

The print stations 132 and 134 print a fifth and a sixth layer 162 on the ticket 50. As shown in FIG. 11, the fifth and sixth layers 162 are printed as discrete sections which overlie the play indicia 74 and the validation number 78. The fifth and

sixth layers 162 are indicated by the shaded areas overlying the play indicia 74 and the validation number 78. The fifth and sixth layers 162 are both substantially transparent release coats which allow the play indica 74 to be viewed by the player and at the same time permit an easy removal of subsequent layers by, for example, rubbing the ticket 50 with a fingernail. The same release coat formula on may be used to print both the fifth and sixth layers 162. A suitable formulation for the third layer is disclosed in Walton, U.S. Patent No. 4,726,608. Also, in some cases it may be desirable to use an ultraviolet curable seal-release coat in place of the release coats 162. Such seal-release coats are well known in the art.

The print station 136 prints a seventh layer 164 which comprises the remainder of the electrical circuit 81 shown in FIG. 2 which is printed on the ticket 50. As illustrated in FIG. 12, the seventh layer 164 is a patterned layer which includes the resistor tracks 82-96 and the conductive areas 98A-H. The seventh layer 164 also includes the conductive bar 106 of the I-track 102 shown in FIG. 2. As explained earlier, the resistor tracks 82-96 are connected to the conductive areas 98A-H. The resistor tracks 82-96, as printed thus have electrical continuity with the conductive areas 98A-H and conductive track 100.

The relationship between the first layer 146 and the seventh layer 164 is better understood with reference to Figs. 19 and 20 which are respectively plan drawings of the first layer 146 and of the seventh layer 164 alone. As noted earlier, the first layer 146, shown by itself in FIG. 19, consists of the blocking cells 152 and the I-track 148. The I-track 148 includes the terminal conductive bar 104 and the resistive bar 107. The seventh layer 164, shown by itself in FIG. 20, consists of the resistive tracks 82-96, the conductive areas 98A-H, the central conductive track 100 and the conductive bar 106. The seventh layer 164 is positioned on the ticket 50 so that the conductive bar 106 of the seventh layer overlies the conductive bar 150 of the first layer 146 to form the partial circuit 81 as illustrated in FIG. 2. The overlying relationship of conductive bars 106 and 150 ensures electrical continuity between the first layer 146 and the seventh layer 164.

It is desirable that the ink used to print the seventh layer 164 have a

sheet resistivity at least in the range of 300 Ω/□ to 600 Ω/□ and preferably, the sheet resistivity should be below 300 Ω/□. Several parameters can be varied to reduce the sheet resistivity of an ink. For example, the shape and size of the conductive particles affects the sheet resistivity of the ink. In addition, metal pigments tend to reduce the sheet resistivity as does a high pigment to binder ratio. However, both metal pigment and a high pigment to binder ratio tend to reduce the graphic adhesiveness of the ink. Unlike the ink used to print the first layer 146, the ink used to print the seventh layer 164 need not have exceptional adhesive properties because the seventh layer 164 or portions thereof are designed to be removed to reveal the play indicia 74 when the ticket 50 is played. Consequently, the ink used to print the seventh layer 164 on the ticket 50, or circuits on other types of documents where the adhesive qualities of the ink are not a major consideration, can include metal particles and can have a relatively high pigment to binder ratio. The use of metal particles in place of or in addition to carbon particles can substantiality increase the conductivity of the ink.

A preferred ink formulation for the seventh layer 164 is given in Table 2.

Table 2: Preferred Conductive Ink Formulation For Layer 7

material	wt %
Acrylic resin	10-15%
Pentaerythritol ester of modified rosin	1-5%
conductive carbon	5-15%
silver plated copper particles (5-10 μ)	10-25%
polyamine amide/acid ester dispersant	0.25-0.75%
anhydrous ethyl alcohol	25-35%
normal propyl acetate	28-38%

Although the preferred metal particles are sliver plated copper particles, other conductive metal particles such as aluminum, brass, nickel, iron and iron oxide particles can be used as well. However, it should be noted that nickel may not be suitable for use in certain types of documents since it can be toxic if ingested. Also, in addition to sliver, the metal particles can be plated with gold or tin.

An eighth layer 168, preferably a scratch-off latex material, is applied at printing station 138. As shown in FIG. 13, the eighth layer 168 covers most of the playing field portion 62 of the ticket 50. The eighth layer 168 does not cover the inventory control number 70 or the bar code 80. The eight layer 168 does, however, overlie the conductive bar 102 of the seventh layer 164. The final printing stations 138, 140, and 142 apply overprint graphics such as overprint areas 66, 68, and 76 illustrated in FIG. 1. The square overprint areas 68 serve to visually identify the individual play spot areas 72A-H and the overprint area 76, which overlies the validation number 78, is printed with the instruction "void if removed."

IV. Measuring The Printed Electrical Signature

A. An External Verification Machine

As stated earlier, the circuit 81 on the ticket 50 is completed when the ticket 50 is capacitively coupled to the external validation or verification machine 108 which then can measure the electrical signature of the circuit elements such as resistors 82-96 on the ticket 50. FIG. 14 is a stylized perspective view of an exterior of the external verification machine 108. Although the exact configuration of the exterior of the extern al verification machine 108 can vary, the exterior of the preferred embodiment of the external verification machine 108 has three features: a results indicator 174, a ticket interface 176, and a user interface 178. As shown in FIG. 14, the results indicator 174 of the external verification machine 108 is a display panel 180. The display panel 180 can display the results of a ticket validation operation and can also display the results of verification testing, including tests of the authenticity and integrity of the ticket 50. The display panel 180 can also display instructions, such as "Insert Ticket", concerning the use of the external verification machine 108. In place of or in combination with the display panel 180, the external verification machine 108 can communicate with a printer 181 shown in Fig. 17 which can display the results of the ticket validation operation and verification testing as well. The user interface 178 can be a keyboard which the player or an agent can use to manually enter data from the ticket into the external verification machine.

A ticket interface 176 of the external verification machine 108 includes a ticket slot 182 into which the ticket 50 can be inserted. When the ticket 50 is properly inserted into the ticket slot 182, the conductive areas 98A-H, 100, and 106 are aligned with an array of capacitor plates 226A-H, 228 and 230, as shown in Fig. 18, located within the external verification machine 108, to complete the partial circuit 81 printed on the ticket 50. In addition, the bar code 80 is aligned with a bar code reader 210 (not shown) located within the external verification machine 108.

FIG. 15 is a stylized plan drawing of an alternative embodiment of an external verification machine 183 having a different type of ticket interface 177. In this embodiment the external verification machine 183 has a hinged lid 184 which can be raised to expose the ticket interface 177 which includes a ticket recess 186. Within the ticket recess 186 is a sensor area 188 containing an array of capacitor plates (not shown) which align with the capacitor areas 98A-H, 100, and 106 on the ticket 50. The ticket recess 186 also includes a bar code reader area 190. The ticket 50 is placed within the ticket recess 186 such that the bar code 80 can be read through reader area 190 by a bar code reader 210 located within the external verification machine 183 as illustrated in Fig. 17. The external verification machine 183 can also have a second sensor area 192 also containing capacitor plates (not shown) which align with the conductive areas 98A-H, 100, and 106 on ticket 50.

FIG. 16 is a plan view of the preferred embodiment of the user interface keyboard 178. The user interface 178 includes a numeric key pad 196 and a set of operation keys 198-204. The operation key 200 is used to input the validation number 78 of the ticket 50 into the external verification machine 108 and the operation key 198 is used to manually input the bar code 80 of the ticket 50 into the external verification machine 108. Keying in of the bar code 80 may be necessary if the bar code reader 210 is not able to read the bar code because, for example, the bar code 80 is damaged or perhaps has been tampered with.

FIG. 17 is a sectioned side view which includes a block diagram of the major internal components of the external verification machine 108. The external verification machine includes the bar code reader 210, and a ticket sensor 212. The

ticket sensor 212 senses when the ticket 50 has been properly inserted so that the bar code 80 can be read by the bar code reader 210. When the ticket is properly inserted the conductive areas 98A-H, 100, and 106 of the ticket 50 are aligned with a pair of sensor plates, indicated at 214 and 216, which include an array of copper capacitor plates 226A-H, 228 and 230, shown in FIG. 18, positioned in a configuration which mirrors that of the conductive or capacitor areas 98A-H, 100, and 106 of the ticket 50. The sensor plates 214, 216 are part of a sensor head 218 which contains a set of excitation and detection circuitry for the external verification machine 108. The external verification machine 108 also includes a processor board 220, including a microprocessor and memory, and a communications interface 222.

The excitation and detection circuitry of the sensor head 218 includes a microcontroller 224 with associated memory as shown in FIG. 18. The microcontroller 224 provides the necessary logic to control the external verification machine 108 and performs various tasks including controlling the communications interface 222, the user interface 178, and the bar code reader 210. The microcontroller 224 also processes the measured electrical signature of the circuit elements 82-96 on the ticket 50 that can be used to determine the authenticity and integrity of the ticket 50. Because the microcontroller 224 requires relatively little processing power, a single, self-contained IC can be used to provide inexpensive processing. Examples of acceptable chips include the Motorola 68HC711E9 and the Intel MCS®-51 Series microcontrollers. Each of these chips includes a Random Access Memory ("RAM") and a Programmable Read Only Memory ("PROM") and an Analog to Digital converter ("A/D").

As is explained in greater detail below, in Section V., the bar code 80 can include information regarding the value of the play indicia 74 of the ticket 50. The bar code reader 210 communicates directly with the microcontroller 224 via an ANSI standard interface, for example, UART. In the preferred embodiment, the bar code reader 210 is a laser scanner.

The communications interface 222 generally is a serial digital interface which may be a driver IC or a modem chip set. As is explained in more detail in Section V. below, the serial digital interface 222 allows the external verification

machine 108 to communicate with a central host computer 223 when necessary to determine the authenticity or integrity of the ticket 50. In the preferred embodiment, a non-standard interface or a low-level encryption is included in the design of the serial digital interface 222 in order to enhance the security of communications between the external verification machine 108 and the central computer 223.

In operation, the excitation and detection circuitry of the sensor head 218 is capacitively coupled with the partial circuit 81 printed on the ticket 50 to complete the circuit 81. Thus, a complete circuit 225 including the partial circuit 81 on the ticket 50, as shown in Fig 21, is completed 81 when the ticket 50 is placed within the ticket slot 182 in the sensor head 218. It should be noted that the excitation and detection circuitry can also be coupled to the ticket 50 by various other methods including: direct coupling, inductive coupling, radio frequency coupling and optical coupling, as described below in Section IV.E.

In the preferred embodiment, the sensor head 218 of the external verification machine 108 is capacitively coupled to the circuit 81 on the ticket 50 to complete the circuit 81. A block circuit diagram of the completed circuit 225 is shown in FIG. 21. As noted earlier, the conductive areas 98A-H, the central conductive track 100, and the conductive bar 106 function as capacitor plates. The sensor head 218 includes an array of the capacitive coupler plates 226A-H, 228 and 230, arranged in the same configuration as the conductive areas 98A-H, 100 and 106. When the ticket 50 is placed in the ticket slot 182, the capacitor plates 226A-H are aligned with the conductive areas 98A-H, the central conductive track 100, and the conductive bar 106 to form capacitors having an air gap dielectric. Alternatively, the capacitive couplers 226A-H, 228 and 230 could be arranged within the external verification machine 108 so that the capacitor plates 226A-H, 228 and 230 are positioned on the side of the ticket 50 opposite the conductive areas 98A-H, 100 and 106. In this configuration, the capacitors formed by coupling the capacitive couplers 226A-H, 228 and 230 to the conductive areas 98A-H, 100 and 106 would have a dielectric contributed both by the air gap and by the ticket substrate and printed layers located between the conductive areas 98A-H, 100, and 106 and the capacitor plates 226A-H, 228 and 230.

As noted earlier, each of the resistor tracks 82-96 is capacitively coupled in series to one of the capacitor plates 226A-H in the sensor head 218 via one of the conductive areas 98A-H. Similarly, a capacitor is formed by the capacitor plate 230 and the central conductive track 100. In addition, the bar code resistor track 107 is connected in series with the capacitor formed by the capacitor plate 228 in the sensor head 218 and the conductive bars 106 and 150 and to the capacitor formed by the conductive track 104 and the capacitor plate 228.

The capacitor plates 226A-H and 228 are connected to a pair of buffer amplifiers 232 and 236. The main buffer amplifier 236 supplies a signal to an integrator 238 in the external verification machine 108 which in turn supplies a signal to the microcontroller 224. The secondary buffer amplifier 232 provides a feed back loop to the capacitor plates 226A-H and 228 and hence the conductive areas 98A-H. The resistor tracks which are not currently being tested by the external verification machine 108 can produce stray capacitance which would interfere with the measured detection signal. To overcome this effect, the secondary buffer amplifier 232 applies the buffered detection signal to the resistor tracks which are not being tested, such as tracks 82-86, 90-96, and 107, to cancel out the effect of the stray capacitances.

The microcontroller 224 is also connected to a digital to analog ("D/A") converter 240 which supplies a signal to a voltage controlled oscillator ("VCO") 242. Because of the size constraints of a typical probability game ticket, such as ticket 50, the capacitance formed by coupling the individual resistor tracks, such as resistor track 88, to the excitation and detection circuitry is small. For example, a capacitor including a conductive track printed with the ink formulation described in Table 2 and having an area of 0.201869 inches^2 would have a capacitance of approximately 9 pF. Consequently, the excitation and detection circuitry includes an inductor 244 to oppose the effect of the capacitive impedance resulting from the small capacitance provided by coupling the capacitive pick-up areas 98A-98H and 104 to the external verification machine 108. The output from the VCO 242 is routed through the inductor 224 and applied to the central conductive track 100 via the excitation coupler 230.

When the ticket 50 is inserted into the external verification machine 108

and the microcontroller 224 is activated, the external verification machine 108 begins a discreet verification process for each resistor track 82-96 and 107. The microcontroller 224 steps an 8-bit output bus 245, which controls the D/A converter 240, from a value of 255 to zero. The DC output voltage from the D/A 240 is then applied to the VCO 242 for conversion to frequency. Thus, the microcontroller 224 produces a stepped series of decreasing excitation frequencies. These stepped excitation frequencies are routed though the inductor 244 and applied to the central conductive track 100 of the ticket 50 via the excitation coupler 230. The excitation signal from the VCO 242 is ultimately applied to each of the eight resistor tracks 82-96 and the bar code resistor track 107. The microcontroller 224 selects an individual resistor track, such as resistor track 88, through solid state switches (not shown) and routes the capacitively coupled detection signal to the dual buffer amplifiers 232 and 236. The main buffer amplifier 236 supplies a buffered voltage to the integrator 238 which converts the AC detection signal to a DC detection signal and applies this DC detection signal to the analog to digital input of the microcontroller 224 for processing.

In this embodiment, the external verification machine 108 uses a iterative resonance seeking algorithm to determine the measured electrical signature for each of the resistor tracks 82-96 and 107. Two registers (not shown), the resonance register and the temporary register, in the microcontroller 224 are used to store successive values of the detection signal. The detection signal is the signal produced when any of the resistor tracks, such as resistor track 88, is coupled to the external verification machine 108 and receives the excitation signal via the central conductive bar 100. The contents of both the resonance and temporary registers are initially set to zero.

The amplitude of the detection signal is ultimately converted to an eight-bit binary value via the integrator 238 and the A/D input of the microcontroller 224. The binary converted detection signal is then stored in the temporary register of the microcontroller 240. and the microcontroller 240 then compares the contents of the two registers. If the contents of the temporary register is less than the contents of the resonance register, the resonance register contains the binary converted equivalent of

the amplitude corresponding to the resonance frequency of the resistor track being tested, such as track 88. Consequently, the frequency of the excitation signal and the contents of the resonance register are output to the processor 220 and in certain cases to the communication interface 222 which includes a UART serial digital port. The output of the communication interface 222 which represents the electrical signature of the resistor track being tested can be transmitted to the central computer 223 or to a lottery terminal (not shown).

If the resonance frequency of the resistor track, such as track 88, is not detected, the above excitation and detection process is repeated. First, the contents of the temporary register are stored in the resonance register. Thereafter, the 8-bit output bus, which controls the D/A converter 240, is decremented to produce an excitation signal from the VCO 242 having a lower frequency than the previously applied excitation signal. The new excitation signal is applied to the ticket via the conductive track 100 and the new detection signal is compared, as previously described, with the contents of the resonance register. This excitation and detection process is repeated for each resistor track 82-96 and 107 until the detection signal corresponding to that associated with the resonance frequency of the resistor track being tested is determined.

B. Candidate Circuits For Providing The Electrical Signature

1. The T-Square Circuit.

Several different types of circuit configurations can be printed on the ticket 50 to provide a measurable electrical signature. In the preferred embodiment, the printed circuit configuration 81, termed a T-square circuit, is illustrated in FIG. 2. As noted earlier, each of the resistor tracks 82-96 is electrically connected to one of the conductive areas 98A-H and to the central conductive track 100. FIG. 20 is a plan drawing of the partial printed circuit used to determine the authenticity and integrity of the play spot areas 72A-H and illustrates the resistor tracks 82-96 connected to the

conductive areas 98A-H and the central conductive track 100. In addition, the bar code resistor track 107 is electrically connected to the conductive bars 104 and 106. FIG. 19 is a plan drawing of the partial printed circuit used to determine the authenticity and integrity of the bar code 80 and illustrates the bar code resistive track 107 connected to the conductive areas 104 and 150. As noted earlier, the first layer 146 printed on the ticket 50 includes the bar code resistor track 107 and the conductive areas 150 and 104. Successive layers, up to and including the sixth layer 162, do not overlie the conductive area 150 thus leaving the conductive area 150 exposed. The seventh layer 166 consists of the partial printed circuit used to determine the authenticity and integrity of the play spot areas 72A-H, as shown in FIG. 20. The conductive bar 106 of the seventh layer 164 immediately overlies the conductive bar 150 of the first layer 146. Consequently, the partial circuit including circuit elements 82-96 and 98A-98H for the play spot areas 72A-H, shown in FIG. 20, and the partial circuit for the bar code 80, shown in FIG. 19, are electrically connected via the conductive bars 106 and 150. Thus, when the ticket 50 is coupled to the external verification machine 108, the excitation signal applied to the ticket 50 via the central conductive track 100 is also transmitted to the bar code resistive track 107 via the conductive bars 106 and 150. Therefore, the completed circuit 225 which is formed when the ticket 50 is capacitively coupled to the sensor head 218 via the conductive areas 98A-H, 100, 104, and 106 is actually nine different, separate circuits, one for each of the resistor tracks 82-96 and one for the bar code resistor track 107.

As is explained in Section V. below, the external verification device 108 tests the integrity of a specific resistor track, such as resistor track 88, by comparing the measured resistance to the resistance which should result from the undisturbed configuration of the resistor track as originally printed, that is, the predetermined electrical signature of the resistor track. If the play spot area overlying the resistor track, such as track 88, has not been altered, for example, rubbed off or lifted to reveal the underlying play indicia, the resistance measured by the external verification machine 108 will be substantially the same as the resistance which should result from the configuration of the resistor track 88 as originally printed. If, however, the play spot

has been removed or lifted, the measured resistance will be substantially different than the predetermined electrical signature of the track 88.

The T-square circuit 200 can determine the authenticity and integrity of the ticket 50 as a whole, of the individual play spot areas 72A-H, and of the bar code 80. If no resistance can be measured for any of the resistor tracks 82-96, it can be assumed that either the ticket 50 is a counterfeit or that all of the play spot areas 72A-H have been rubbed off thereby rendering the ticket 50 void. Moreover, because the T-square circuit 200 provides a different individual circuit for each of the resistor tracks 82-96, the T-square circuit 200 can individually test the integrity of the individual play spot areas 72A-H.

For example, a particular probability game may require revealing three matching game indicia to win. In addition, the game rules may require that no more than three play spot areas be rubbed off to reveal the underlying indicia. Consider the hypothetical situation in which an individual presents the ticket 50 to a lottery agent for redemption because the individual has ostensibly rubbed off only three play spot areas and the indicia in the three play spot areas match. By pure visual inspection, the ticket 50 might appear to be a valid and winning ticket. However, when the ticket 50 is inserted into the ticket slot 182 of the external verification machine 108 to measure the resistance of the play spot areas 72A-H, the external verification machine 108 would determine that not only the measured resistances of the three rubbed-off play spot areas differ from the predetermined resistances for these play spot areas, but also that the measured resistance of other "non-rubbed-off" play spot areas differ from the predetermined resistances for these areas. This situation could arise, for example, when the individual removes the overprint areas 68 of these additional play spot areas to reveal the hidden indicia 74 and then attempts to replace the overprint areas 68 so that these play spot areas appear to not have been played. Thus, although visually the ticket 50 appears to be a valid winning ticket, the measure of the resistances 82-96 would indicate that more than three play spot areas have been removed and that therefore the ticket 50 is void. In addition, if the measured resistance of the bar code resistor track 107 is substantially different from the predetermined electrical signature for the bar

code 80. it can be assumed that the bar code 80 has been tampered with as well.

2. The Binary Coupled Circuit.

An alternative embodiment of a ticket 250 having a partial printed circuit 252, termed a binary coupled circuit, is shown in FIG. 21. The partial circuit 252 is analogous to the seventh layer 164 printed on the ticket 50. As with ticket 50, the partial circuit 252 is ultimately printed on a ticket substrate 254 preferably using a conductive ink of the type described in Table 2. Although not shown, it is to be understood that additional layers such as a lower conductive layer analogous to the first layer 146 of ticket 50, a blocking layer and a primer layer analogous to the second layer 156 and third layer 158 of the ticket 50, play indicia analogous to the play indicia 74 of ticket 50, a seal coat and release coats analogous to the fourth layer 160 and the fifth and sixth layers 162 of the ticket 50 are also printed on the ticket 250 between the substrate 254 and the partial circuit 252 in a manner similar to that used for ticket 50.

The ticket 250 includes a display portion 256 and a playing field portion 258. The display portion 256 is ultimately covered by a coating (not shown) suitable for receiving customized graphics (not shown) and information (not shown) related to the rules for playing the ticket 250. The playing field portion includes two columns of four, separately removable play spot areas 260-274. Within the playing field portion 258, the partial circuit includes several conductive areas 276-292 and eight resistor tracks 294-308. Each of the play spot areas 260-274 is positioned between two conductive areas, for example, play spot area 260 is positioned between conductive areas 276 and 278 and play spot area 262 is positioned between conductive areas 278 and 280. Each of the resistor tracks 294-308 is also positioned between and electrically connected to two of the conductive areas 276-292. For example, resistor track 294, associated with play spot area 260, is positioned between and connected to conductive areas 276 and 278. Underlying each of the play spot areas 260-274 is a conductive line (not shown). Each conductive line is connected to the two conductive areas associated with its respective play spot area and resistor track. For example, the conductive line underlying play spot area 260 is connected to conductive areas 276 and 278.

The three additional conductive areas 310-314 are printed in the display

portion 256 of the ticket 250. The first conductive area 310 is connected to the first column of four play spots 269-266 via a conductive track 316 connected to the conductive area 284. The second conductive area 312 is connected to the second column of four play spots 268-274 via a second conductive track 318 connected to the conductive area 292. All eight play spot areas 260-274 are connected to the third conductive area 314 via a third conductive track 320 connected to the conductive area 276. The conductive areas 310-314 serve as capacitor plates when the ticket 250 is coupled to an external verification machine.

Each column of four play spot areas 260-266 and 268-274 forms one complete circuit when the ticket 250 is coupled to the external verification machine 108. The excitation signal from the external verification machine 108 is routed through each group of four play spot areas 260-266 via the common conductive area 314 in the display portion 256 of the ticket 250. Each group of four play spot areas 260-266 and 268-274 provides its own detection signal. The detection signal for the play spot areas 260-266 is coupled to the external verification machine 108 via the conductive track 316 and the conductive area 310. The detection signal for play spot areas 268-274 is coupled to the external verification machine 108 via the conductive track 318 and the conductive area 312.

Within a group of four play spot areas, for example play spot areas 260-266, the magnitude of the detection signal varies with the integrity of each of the play spot areas 260-266. If the play spot areas 260-266 are intact, the excitation signal is substantially unaltered and is routed through the conductive lines underlying each of the play spot areas 260-266. However, if a play spot area has been rubbed off or lifted to reveal the underlying play indicia, the signal is routed through the resistor track associated with that play spot area. For example, if play spot area 260 is intact, the signal proceeds through the underlying conductive bar to the conductive area 278. However, if the play spot area 260 has been at least partially removed to reveal the underlying play indicia, the circuit through the conductive line is broken thus routing the signal through the associated resistor track 294 thus changing the characteristics of the detection signal.

In the preferred embodiment of this ticket 250 , each of the resistor tracks associated with a group of four play spot areas, such as the resistor tracks 294-300 associated with play spot areas 260-266 has a unique predetermined resistance that is related, in a binomial progression, to the other resistor tracks in the column. For example, resistor track 294 can have a predetermined electrical signature equal to a resistance of 100 KΩ, resistor track 296 can have a predetermined electrical signature equal to a resistance of 200 KΩ, resistor track 298 can have a predetermined electrical signature equal to a resistance of 400 KΩ, and resistor track 300 can have a predetermined electrical signature equal to a resistance of 800 KΩ. The resistor tracks, such as resistor tracks 294-300, are printed in parallel to the conductive lines underlying the play spot areas, such as play spot areas 260-266. As explained below, the binomial relationship of the printed resistances for each resistor track within a group of four resistors tracks permits determination of the integrity of each play spot even though only one detection signal is produced for all four resistor tracks.

FIG. 22 is a partial schematic circuit diagram 324 illustrating the coupling of one column of four resistor tracks 260-266 to the excitation and detection circuitry of the external verification machine 108. The parts of the circuit which are contributed by the ticket 250 include the four resistor tracks 294-300, the conductive areas 276-284, the conductive lines 316 and 320, and the conductive areas 314 and 310. In addition, the ticket partial circuit includes four conductive lines 326-332 which underlie the play spot areas 260-266. The play spot areas 260-266 do not actually form a part of the circuit but are included in FIG. 22 for ease of understanding.

The remainder of the excitation and detection circuit is provided by the external verification machine 108, including a pair of capacitor plates 334 and 336. The capacitor plates 334 and 336 can consist of, for example, copper plates positioned within the external verification machine 108 to mirror the configuration of the conductive areas, such as conductive areas 310 and 314, on the ticket 250. When the ticket 250 is coupled to the external verification machine, the excitation and detection circuit is completed by the capacitive coupling of the capacitor plates 334 and 336 in the external verification machine with the conductive areas 314 and 318 printed on the

ticket 250. The excitation signal is applied to the ticket 250 via one of the capacitors formed by one of the capacitor plates, for example the capacitor 334, with the conductive area 314 printed on the ticket 250. The detection signal is routed to the rest of the excitation and detection circuit via the capacitor formed by the other capacitor plate in the external verification machine, for example plate 338, with the conductive area 310 printed on the ticket 250.

When the play spots 260-266 have not been removed or tampered with, as illustrated in FIG. 22, the excitation signal flows through the each of the four conductive lines 326-332. However, removing or partially removing one of the play spots 260-266 effectively breaks the circuit through the associated conductive line rerouting the signal through the associated resistor track. For example, if play spot 260 is removed, the signal pathway would go through resistor track 294. Because each resistor track 294-300 has its own unique resistance, each resistor track 294-300 produces its own unique detection signal thereby permitting the external verification machine 108 to identify which, if any of the play spot areas 260-266 have been lifted or removed. Moreover, since the resistance values of the resistor tracks 294-300 are related to each other as a binomial progression, the external verification machine 108 can also identify which of the play spots 260-266 have been removed when two or more of the play spots 260-266 have been removed. For example, if both play spots 260 and 262 are removed the combination of resistor tracks 294 and 296 adds 300 KΩ to the excitation and detection circuit. However, if play spots 260 and 264 are removed, the combination of resistor tracks 294 and 298 adds 500 kΩ to the excitation and detection circuit. Thus, because the resistor tracks 294-300 have resistance values that are related as a binomial progression, each possible combination of resistor tracks 294-300 results in a unique total resistance which can be used to identify the play spots 260-266 that have been removed. Table 3 lists all the possible combinations of resistor tracks 294-300 and the resulting resistance values for the previously identified resistance values for the resistor tracks 294-300.

Table 3: Resistor Combinations

Resistors In The Circuit	Effective Resistance

R1	100
R2	200
R3	400
R4	800
R1 + R2	300
R1 + R3	500
R2 + R3	600
R1 + R2 + R3	700
R1 + R4	900
R2 + R4	1000
R1 + R2 + R4	1100
R3 + R4	1200
R1 + R3 + R4	1300
R2 + R3 + R4	1400
R1 + R2 + R3 + R4	1500

Additional resistance values and combinations of resistance values are possible. For example, the resistance values in Table 3 could be increased or decreased by an order of magnitude. The principle of this circuit design is that the individual resistance of each resistor track within a group of resistor tracks, such as resistor tracks 294-300, should be algorithmically related to the resistances of the other resistor tracks within the group so that every combination of resistor tracks provides a unique total resistance. Preferably, the individual resistances should vary as a binomial progression.

3. <u>The Infinite Resistance Circuit.</u>

FIGS. 23, 24, 25 and 26 illustrate another partial printed circuit which can be used to validate and determine the authenticity and integrity of a document which in this example is a lottery ticket 340. As shown in FIG. 23, the lottery ticket includes play indicia 342 which are printed over the ticket substrate 344. Additional information, such as the name of the lottery game 346 and rules 348 for playing the ticket are also printed on the ticket substrate 344. FIG. 24 is a plan drawing of the scratch-off coating 350 which is printed over and conceals the play indicia 342. The scratch-off coating 350 is a removable layer of a material such as latex which can be relatively easily removed to reveal the play indicia 342. A single block of scratch-off coating 350 is used to cover all of the play indicia 342. A release coat (not shown)

coincident with the scratch-off coating 350 is also printed on the ticket 340 between the play indicia 342 and the scratch-off coating 350. FIG. 25 is a plan drawing of the partial printed circuit which is used to determine the integrity and authenticity of the ticket 340. The circuit consists of a single conductive area indicated at 352A and 352B which overlies the scratch-off coating 350. The two portions 352A, 352B of the conductive area extend beyond the edges of the scratch-off coating 350. FIG. 26 is a plan drawing of the ticket 340 in its final printed state which includes overprint areas 354 that conceal the scratch-off coating 350 and the conductive area 352, as well as overprint areas 356 that define the individual play spot areas.

When the ticket 340 is coupled to the external verification machine 108 the portions 352A and 352B serve as capacitor plates to couple the partial circuit printed on the ticket 340 with the excitation and detection circuitry in the external verification machine 108. The portion of the conductive track 352A-B which immediately overlies the scratch-off coating 350 but does not extend beyond the scratch-off coating 350 serves as a resistor track when the ticket 340 is coupled to an external verification machine 108. If the ticket is in its original integral state, the portion of the conductive area 352A-B immediately overlying the scratch-off layer 350 is electrically connected to the portions 352A and 352B which serve as capacitor plates. However, if an individual has attempted to surreptitiously inspect the play indicia 342 by, for example, lifting and then replacing the scratch-off layer 350, the electrical connection between the middle portion of the conductive layer and the end portion 352A and 352B would be broken resulting in an open circuit.

4. The Increased Resistance Circuit.

FIG. 27 illustrates an alternative embodiment of a scratch-off layer 358 for the ticket 340. Unlike the previously described scratch-off layer 350, the scratch-off layer 358 consists of discreet, individual areas which overlie each play indicia 342 (not shown). A release coat (not shown) underlies each of the discreet portions of the scratch-off coating 358. The partial printed circuit which overlies the scratch off layer 358 consists of a single conductive area indicated at 360A and 360B which overlies all

of the scratch off layer 358. Two portions 360A, 360B of the conductive area 360 extend beyond the area of the ticket 340 containing the scratch-off coating 358. The final printed format of the ticket 240 is shown in FIG. 26 and includes overprint areas 354 that conceal the scratch-off coating 358 and the conductive area 360A-B, as well as overprint areas 356 that define the individual play spot areas.

When the ticket 340 is coupled to an external verification machine 108, the portions 360A and 360B of the conductive area 360 which extend beyond area of the ticket 340 containing the scratch-off layer 358 serve as capacitor plates to couple the partial circuit printed on the ticket 340 with the excitation and detection circuitry in the external verification machine 108. The portion of the conductive area 360A-B which immediately overlies the scratch-off coating 358 but does not extend beyond the scratch-off coating 358 serves as a resistor track when the ticket 340 is coupled to the external verification machine 108. If all of the play spots are intact, the electrical signature of the ticket 340 will be equal to the printed resistance associated with the portion of the conductive track 360 which overlies all of the play indicia 342. However, if an individual has attempted to surreptitiously inspect the play indicia 342 by, for example, lifting and then replacing one portion of the scratch-off layer 358, the small portion of the conductive area 360A-B immediately overlying the removed area of the scratch-off layer 258, will be electrically disconnected from the remainder of the conductive area 360A-B, leading to an increase in the resistance associated with the conductive area 360A-B.

5. The Waffle Circuit.

Fig. 29 is a plan drawing of another partial circuit 364 which can be printed on a lottery ticket to determine the authenticity and integrity of the play spot areas. The partial circuit, termed a waffle circuit, includes two conductive bars 366 and 368 which are electrically connected to a conductive area 370 overlying the play indicia (not shown). Removable scratch-off areas 372 overlie the portions of the conductive area 370 which immediately overlie the individual play indicia. A seal coat and release coats analogous to the forth layer 160 and the fifth and sixth layers

162 of the ticket 50 in FIG. 11 are printed in an appropriate configuration between the play indicia and the conductive area 370. Thus, removal of any of the scratch-off areas 372 also removes a portion of the conductive area 370. When the ticket which includes the partial circuit 364 is coupled to the external verification machine 108, each of the play spot areas defined by the scratch-off areas 372 serves as a capacitor plate. In addition, the conductive bars 366 and 368 also serve as capacitor plates to couple the partial circuit 364 to the excitation and detection circuitry of the external verification machine 108. The excitation and detection circuitry of the external verification machine 108 in turn includes an array of capacitive couplers which are positioned to mirror the configuration of the conductive bars 366 and 368 and the scratch-off areas 372. Thus, in contrast to the previously described partial circuits in FIGS. 20., 21, and 23-28, the electrical signature of the play spot areas associated with the partial circuit 364 is a conductive track, rather than a resistive track.

The external verification machine 108 can check the authenticity and integrity of the play spot areas defined by the scratch--off areas 372 by applying an AC excitation signal to one of the conductive bars 366 or 368. If the individual play spot area being tested is intact, the excitation signal will be routed through the portion of the conductive area 370 underlying the scratch-off area 372 associated with the tested play spot area. Consequently, an AC detection signal will be routed to the capacitor plate in the external verification machine 108 which mirrors the particular play spot area 372. However, if the scratch-off area 372 being tested has been at least partially removed, the associated removal of a portion of the conductive area 370 creates an open circuit under that particular scratch-off area 372. Hence, no AC detection signal is routed to the associated capacitor plate in the external verification machine 108, indicating that the integrity of the play spot area 372 has been changed.

6. <u>The Recursive Circuit.</u>

FIG. 30 is another plan drawing of a partial printed circuit 376 which can be used to determine the authenticity and integrity of the play spot areas of a lottery ticket. The partial circuit 376 includes resistor tracks (not shown) which underlie each

of the removable scratch-off areas 378. Each resistor track is electrically connected to a pair of conductive bars 380A and 380B. In the partial circuit shown in FIG. 30, there are a total of twenty-four conductive bars 380A, 380B, two for every resistor track associated with one of the scratch-off areas 378. When the ticket which includes the partial circuit 376 is coupled to an external verification machine 108, each resistor track associated with each scratch-off area 378 is capacitively coupled to the excitation and detection circuity of the external verification machine 108 by its associated conductive bars 380A and 380B. One conductive bar, for example, bar 380A, is used to apply the excitation signal to the resistor track. The second conductive bar, for example bar 380B, routes the detection signal to the rest of the excitation and detection circuitry in the external verification machine 108. If the scratch-off area 372 being tested is intact, the electrical signature of the associated resistor track will be substantially equal to the printed resistance of the resistor track underlying the scratch-off area 372. If, however, the scratch-off area 372 being tested has been at least partially removed or lifted, the measured resistance of the resistor track and hence the resonant frequency of the completed circuit associated with the scratch-off area 372 will be substantially different than the printed resistance of the resistor track.

C. Variation In Printed Resistances

1. <u>Variations In The Printed Resistances.</u>

A number of the foregoing circuits, such as the T-square circuit shown in FIG. 20., and the binary-weighted circuit shown in FIG. 21, use the resistance of a printed resistor track to impart an electrical signature to a document. As noted earlier, the resistance of such printed resistor tracks can be defined as follows:

$$R = \rho(L/A)$$

where R = resistance;
ρ = bulk resistivity (resistance per unit volume);
L = length of resistor; and
A = cross sectional area of the resistor.

The cross-sectional area of the resistor in turn equals the product of the print thickness

predetermined area of the lottery ticket; and

validation means, responsive to said excitation signal, for determining the location of the scratch-off coating in said predetermined area.

83. The machine of Claim 82 wherein said validation means additionally generates a validation signal indicating that at least a predetermined portion of the scratch-off coating has been removed from said predetermined area of the ticket.

84. The machine of Claim 82 wherein said validation means includes at least one sensor aligned in a predetermined position with respect to the ticket by said document interface means and detection means operatively connected to said sensor for generating a detection signal, in response to said excitation signal, indicating the presence of the scratch-off coating associated with said sensor.

85. The machine of Claim 82 wherein said validation means additionally includes verification means for determining if the lottery ticket contains conductive material other than the conductive material in the scratch-off coating.

86. The machine of Claim 85 wherein said verification means generates a verification signal if the lottery ticket contains more than a predetermined amount of the conductive material other than the conductive material in the scratch-off coating.

87. The machine of Claim 86 wherein said predetermined amount of the conductive material other than the conductive material in the scratch-off coating is located on a predetermined area of the upper surface of the lottery ticket.

88. The machine of Claim 84 wherein said validation means includes memory means for storing a representation of the predetermined area and comparing means for comparing said representation to said detection signal.

89. The machine of Claim 88 wherein said comparison generates a validation signal if said detection signals correspond to less than a predetermined portion of said representation.

90. The machine of Claim 89 wherein said validation signal represents at least a predetermined percentage of the scratch-off coating has been removed from the ticket in the predetermined area.

91. The machine of Claim 89 wherein said representation is a digital map of the predetermined area stored in said memory means.

92. The machine of Claim 91 wherein said validation means additionally includes

verification means responsive to said detection signal for determining if the lottery ticket contains conductive material other than the conductive material in the scratch-off coating.

93. The machine of Claim 92 wherein said verification means generates a verification signal if the lottery ticket contains more than a predetermined amount of the conductive material other than the conductive material in the scratch-off coating.

94. The machine of Claim 93 wherein said predetermined amount of the conductive material other than the conductive material in the scratch-off coating is located on a predetermined area of the upper surface of the lottery ticket.

95. The machine of Claim 88 wherein said memory includes a plurality of said representation of predetermined areas and additionally including ticket identification means for identifying which of said representations of predetermined areas corresponds to a particular lottery ticket.

96. The machine of Claim 95 wherein said identification means includes a bar code reader for reading a ticket identifying code bar code on the lottery ticket.

97. The machine of Claim 89 wherein said sensor includes an array of sensor plates.

98. The machine of Claim 89 wherein document interface means includes transport means for moving the upper surface of the lottery ticket past said array of sensor plates.

99. The machine of Claim 26 wherein said excitation plate and said sensor plates are coated with a dielectric material and wherein the upper surface of the lottery ticket is in contact with said sensor plates when said transport means moves the upper surface pat said sensor plates.

100. The machine of Claim 99 wherein said dielectric material has a dielectric constant of approximately 8.

101. The machine of Claim 99 wherein said transport means includes a pressure roller for maintaining the upper surface of the lottery ticket in contact with said sensor plates.

102. The machine of Claim 98 wherein said transport means moves said ticket in discrete steps past said array of sensor plates and said detection signals are generated for each of said sensor plates for each of said steps.

103. The machine of Claim 102 wherein said transport means includes a pressure roller for maintaining the upper surface of the lottery ticket in contact with said sensor plates.

104. The machine of Claim 98 wherein said transport means maintains said scratch-off

coating within a predetermined distance of said sensor plates.

105. The machine of Claim 105 wherein said predetermined distance is 0.004 inches.

106. The machine of Claim 98 wherein said excitation means includes an excitation plate for applying said excitation signal to the predetermined area on the lottery ticket.

107. The machine of Claim 106 wherein said excitation plate is aligned in parallel with and spaced apart from said sensor plates.

108. The machine of Claim 106 wherein said excitation is an AC signal and wherein said validation means includes A/D means connected to said sensor plate for converting the current of said detection signal generated on said sensor plates in response to said excitation signal to a digital detection signal.

109. The machine of Claim 108 wherein said representation is a digital map of the predetermined area stored in said memory means and wherein said comparing means compares said digital detection signal from each of said sensor plates to a corresponding position in said digital map for each of said step of said transport means.

110. A pull-tab lottery ticket validation machine, for use with a lottery ticket having a substrate with play indicia printed thereon and a pull tab member having conductive ink printed thereon secured to the substrate with perforated pull-tabs located over the play indicia, comprising:

document interface means for receiving the pull-tab ticket;

excitation means for applying an excitation signal to selected portions of the pull-tab ticket;

validation means, responsive to said excitation signal, for determining if one or more of the pull-tabs has been removed from the pull-tab ticket.

111. The machine of Claim 110 wherein said validation means includes at least one sensor plate aligned with the location of the pull-tabs on the ticket and signature means operatively connected to said sensor plate for detecting, in response to the application of said excitation signal, a pull-tab signature resulting from the presence of the conductive ink thereby indicating the presense of the pull-tab.

112. The machine of Claim 111 wherein said signature means additionally includes verification means for detecting a verification signature indicating the presence of the conductive ink in an area of the ticket other than the pull-tabs in order to verify that the ticket

is a legitimate pull-tab ticket.

113. The machine of Claim 111 wherein said excitation means includes at least one excitation plate for applying said excitation signal to the ticket.

114. The machine of Claim 113 wherein said document interface means includes transport means for moving each of the locations on the ticket where the pull-tabs would be located past said sensor plate and wherein said signature means generates said pull-tab signature if a pull-tab is present at each of the locations.

115. The machine of Claim 114 wherein said signature means additionally includes verification means for detecting a verification signature indicating the presence of the conductive ink in locations of the ticket other than the pull-tab locations in order to verify that the ticket is a legitimate pull-tab ticket.

116. The machine of Claim 115 wherein said transport means steps the pull-tab ticket such that each of the pull-tab locations is aligned with said sensor plate and said excitation signal is applied to generate said pull-tab signature for each of the pull-tab locations and wherein said transport means steps the pull-tab ticket such that said sensor plate is aligned with at least one predetermined location on the pull-tab ticket other than the pull-tab locations and said excitation signal is applied to generate said verification signal for the predetermined locations.

117. The machine of Claim 116 wherein at least some of the predetermined locations are locations on the pull-tab ticket between the pull-tabs.

118. The machine of Claim 117 wherein said sensor plate is located such that said transport means will move the centerline of the pull-tab ticket past said sensor plate.

119. The machine of Claim 118 wherein said excitation means includes two of said excitation plates aligned with and spaced apart on either side of said sensor plate.

Fig. 1

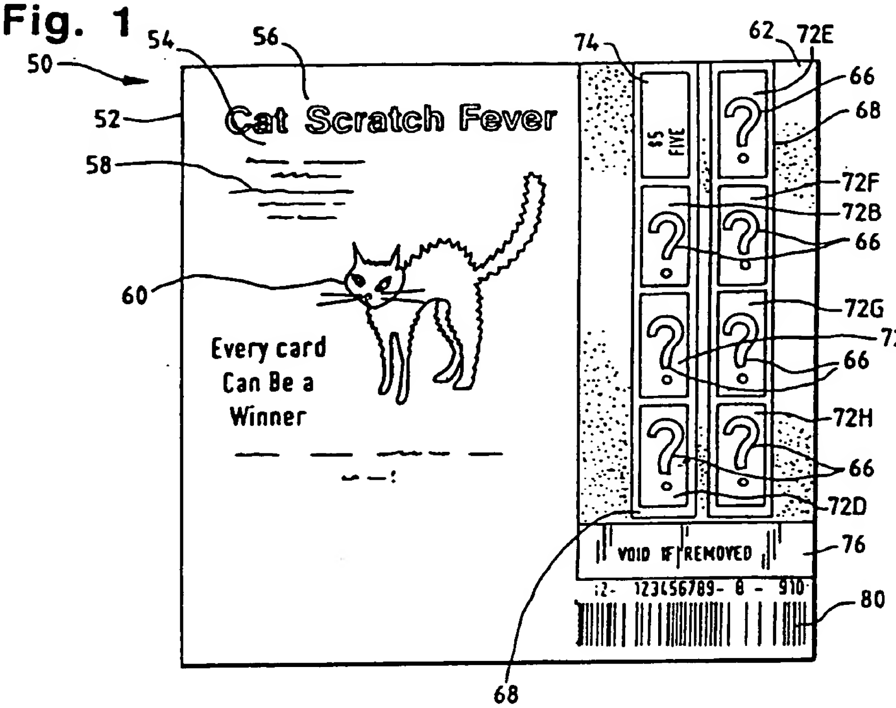

50
52
54
56
58
60
Cat Scratch Fever
Every card
Can Be a
Winner
74
62
72E
66
68
72F
72B
72G
72C
72H
72D
$5
FIVE
VOID IF REMOVED
76
80
68

Fig. 2

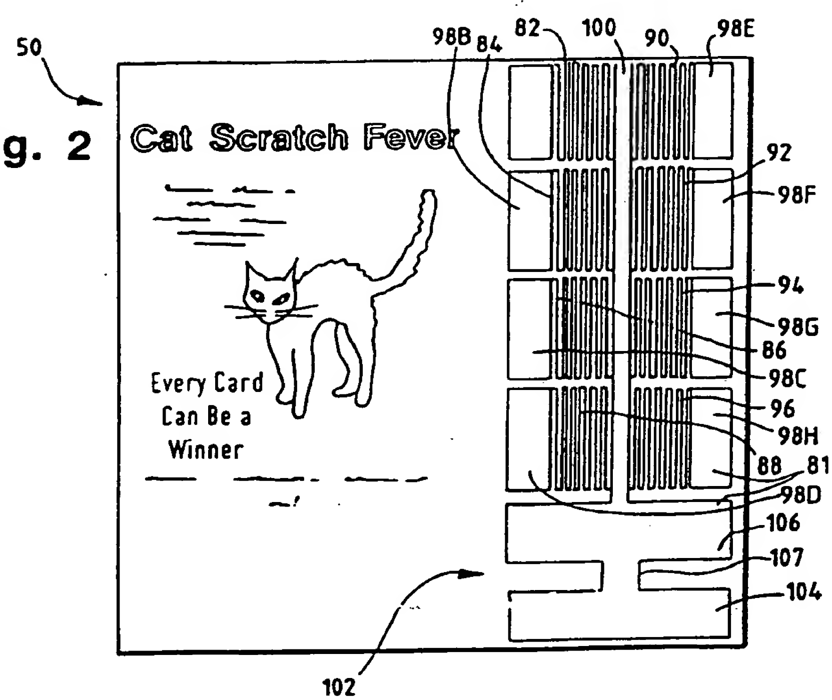

50
Cat Scratch Fever
Every Card
Can Be a
Winner
98B
84
82
100
90
98E
92
98F
94
98G
86
98C
96
98H
88
81
98D
106
107
104
102

Fig. 3

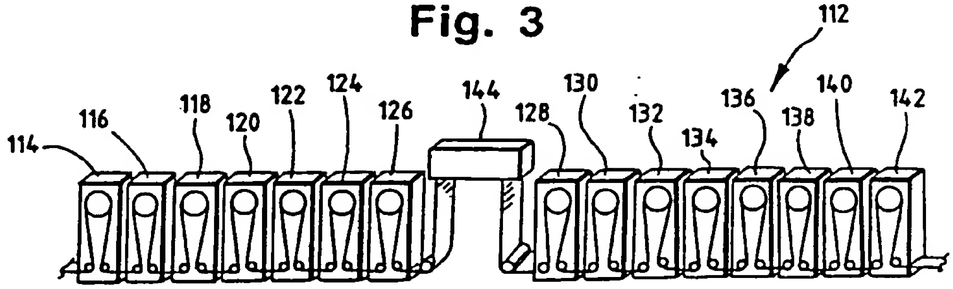

112
114
116
118
120
122
124
126
144
128
130
132
134
136
138
140
142

Fig. 4

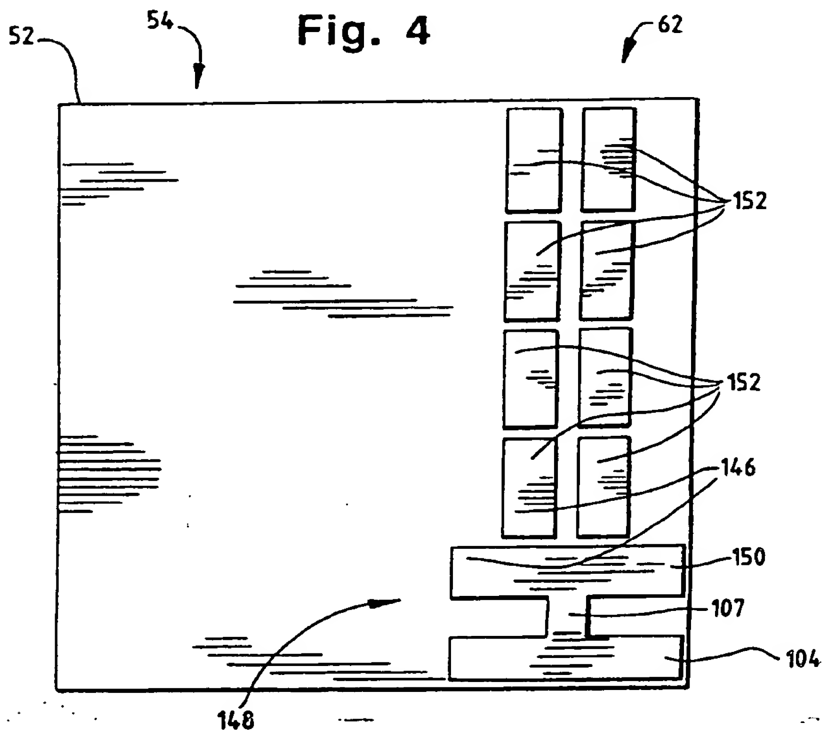

52
54
62
152
152
146
150
107
104
148

Fig. 5

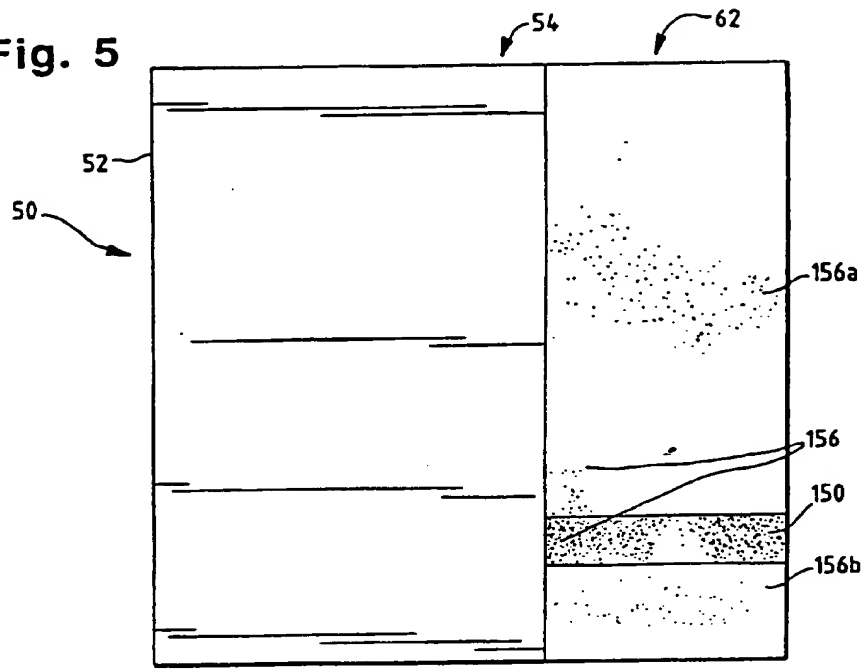


Fig. 6

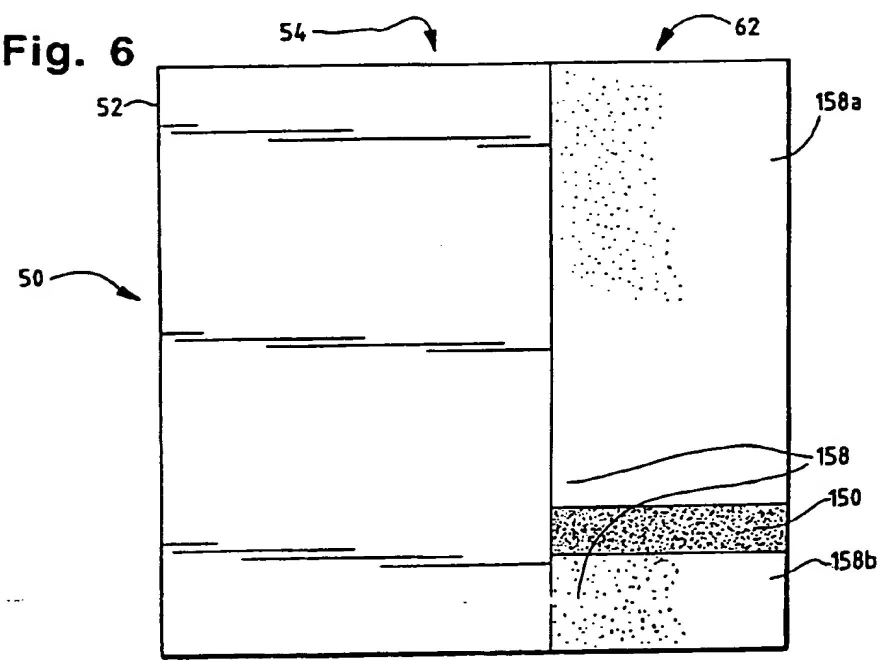


Fig. 7

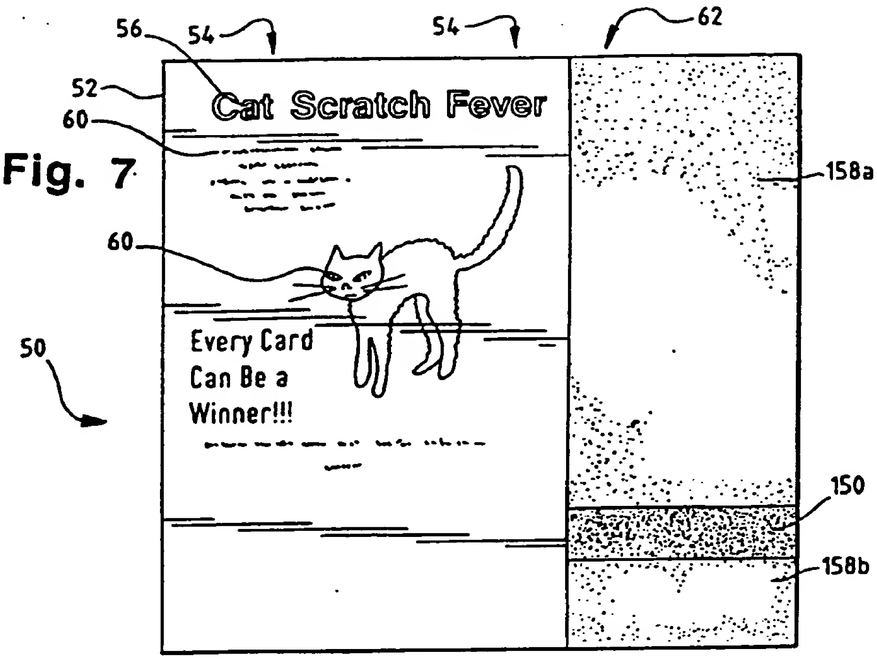

Cat Scratch Fever
Every Card Can Be a Winner!!!
56
54
54
62
52
60
60
50
158a
150
158b

Fig. 8

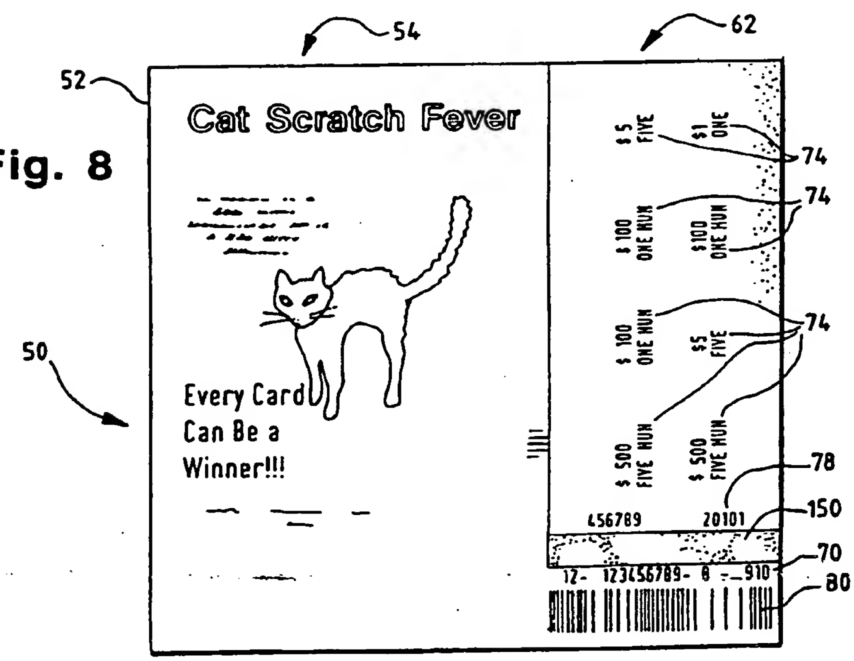

Cat Scratch Fever
Every Card Can Be a Winner!!!
54
62
52
50
74
78
150
70
80
$5 FIVE
$1 ONE
$100 ONE HUN
$5 FIVE
$500 FIVE HUN
456789
20101

Fig. 9

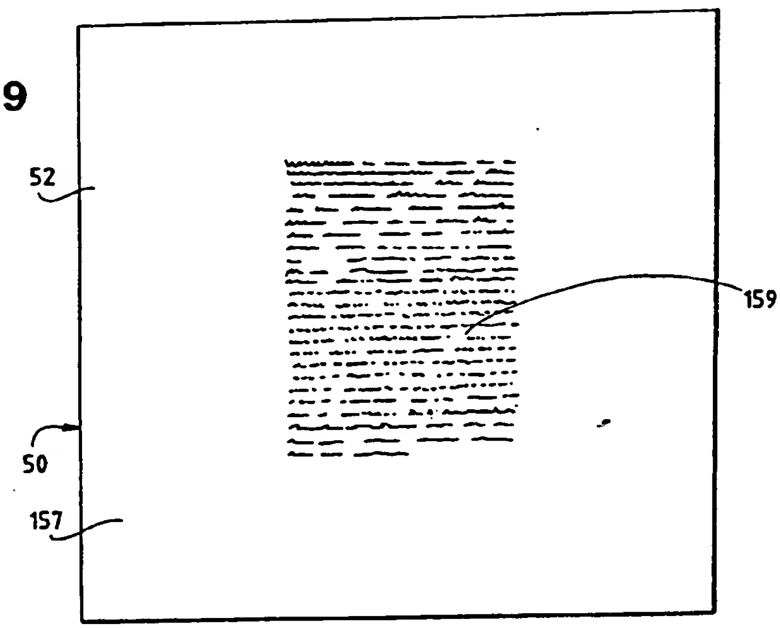

52
159
50
157

Fig. 10

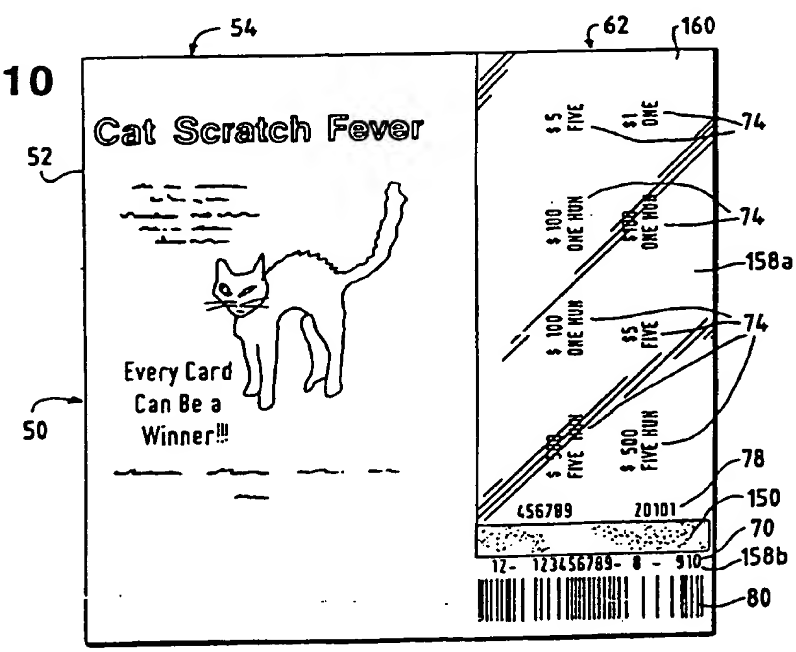

54
62
160
Cat Scratch Fever
Every Card Can Be a Winner!!!
52
50
$5 FIVE
$1 ONE
74
$100 ONE HUN
$100 ONE HUN
158a
$100 ONE HUN
$5 FIVE
$500 FIVE HUN
$500 FIVE HUN
78
456789
20101
150
70
12- 123456789- 8 - 910
158b
80

Fig. 11

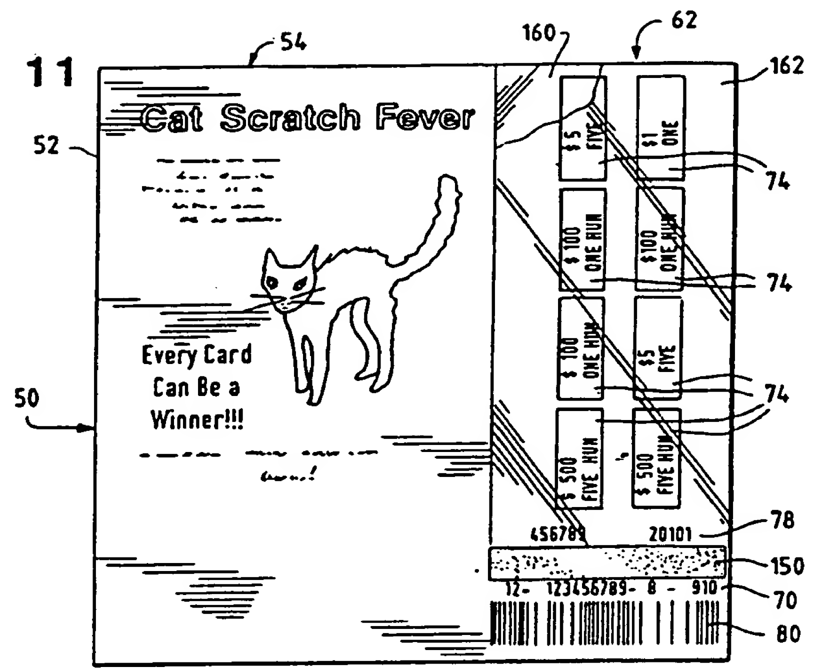

Cat Scratch Fever
Every Card Can Be a Winner!!!
$5 FIVE
$1 ONE
$100 ONE HUN
$100 ONE HUN
$100 ONE HUN
$5 FIVE
$500 FIVE HUN
$500 FIVE HUN
456789
20101
12- 123456789- 8 - 910
54
160
62
162
52
74
74
74
50
78
150
70
80

Fig. 12

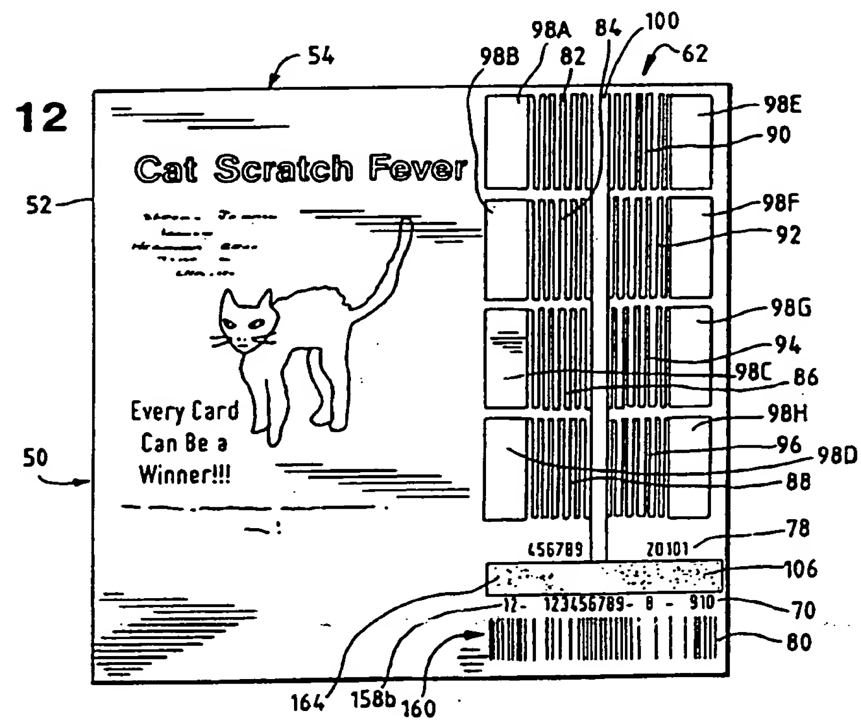

Cat Scratch Fever
Every Card Can Be a Winner!!!
456789
20101
12- 123456789- 8 - 910
54
98A
84
100
98B
82
62
98E
90
52
98F
92
98G
94
98C
86
98H
96
98D
88
50
78
106
70
80
164
158b
160

Fig. 13

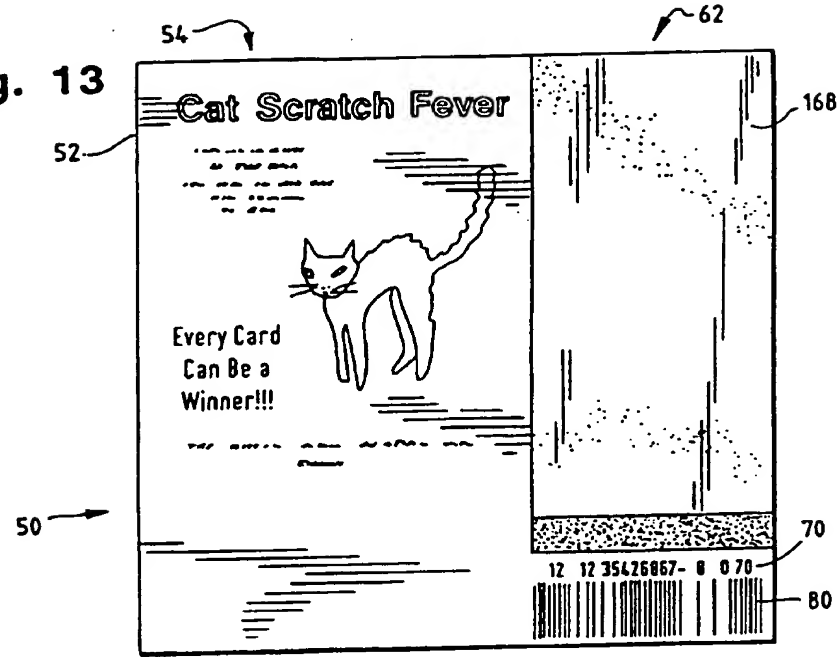


Fig. 14

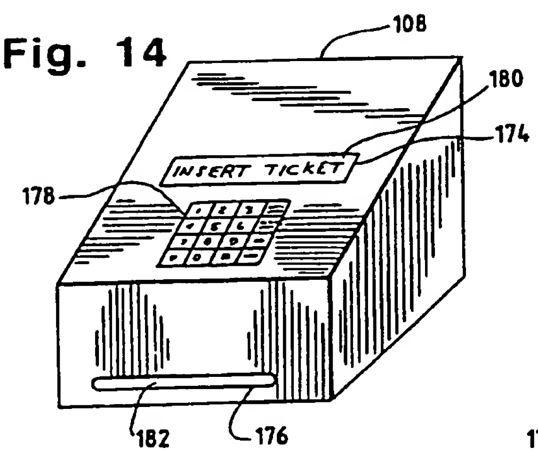


Fig. 15

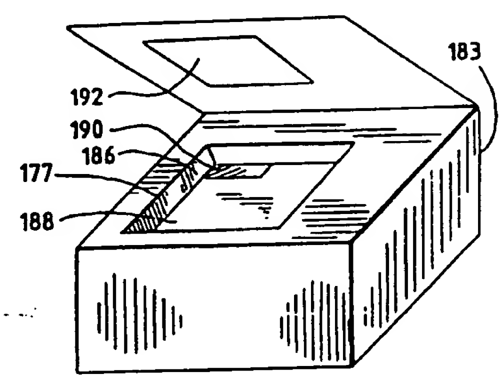


Fig. 16

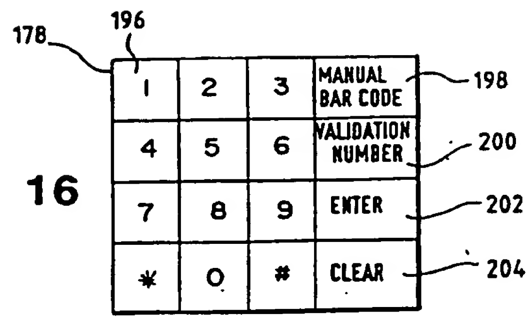
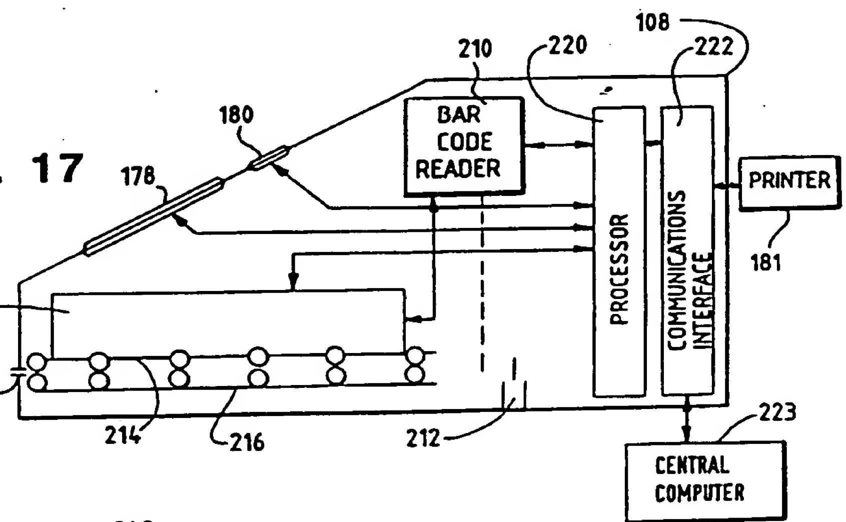


Fig. 17



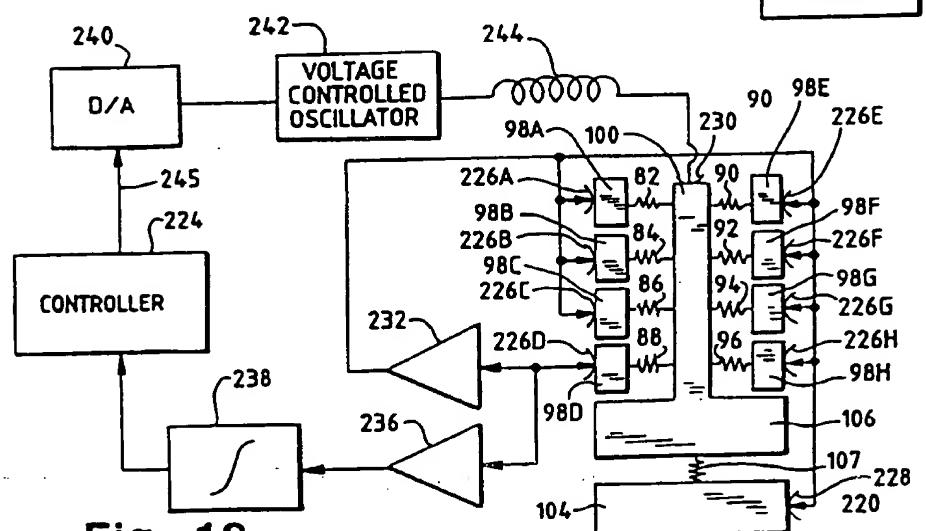


Fig. 18

Fig. 19

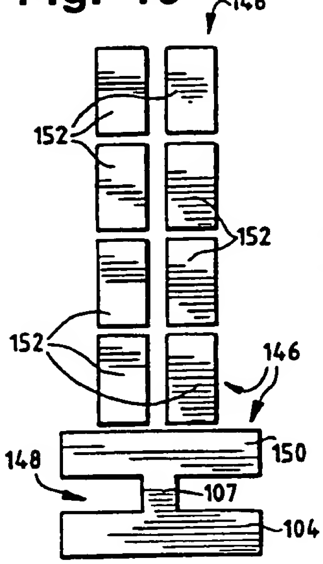


Fig. 20

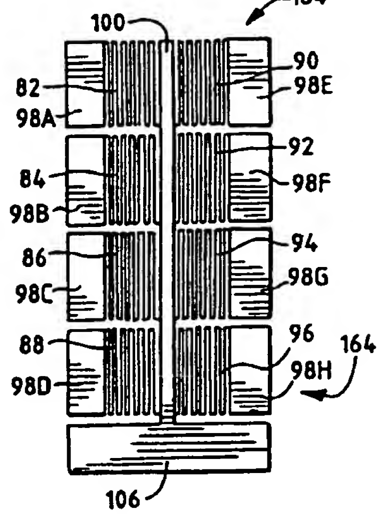


Fig. 22

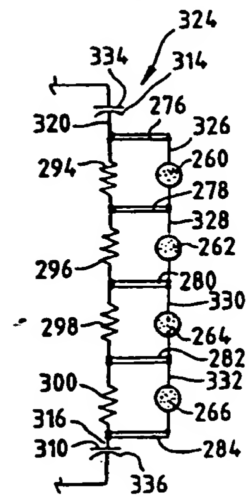


Fig. 21

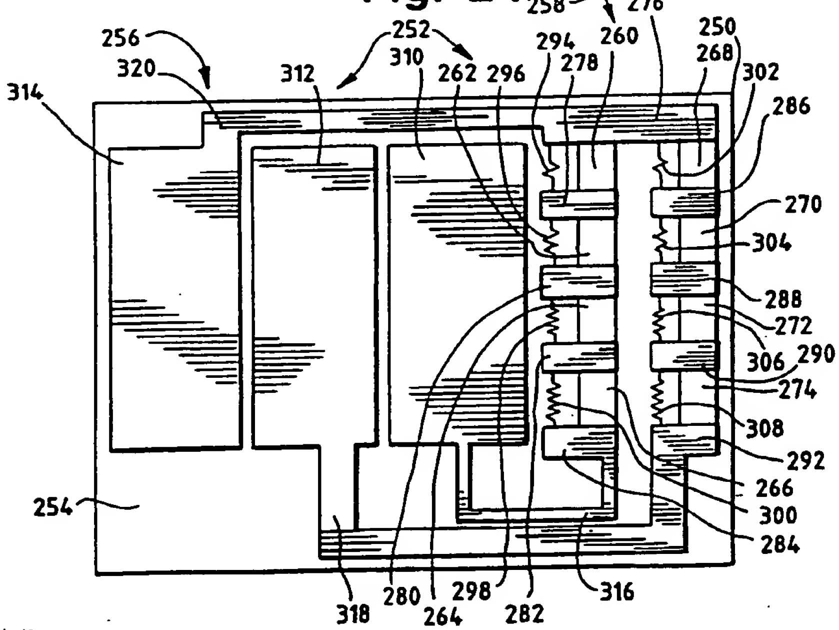


Fig. 23

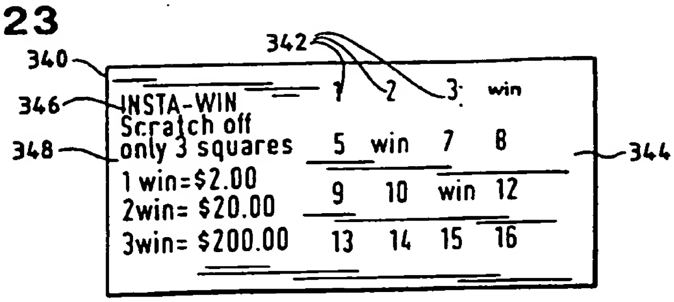


Fig. 24

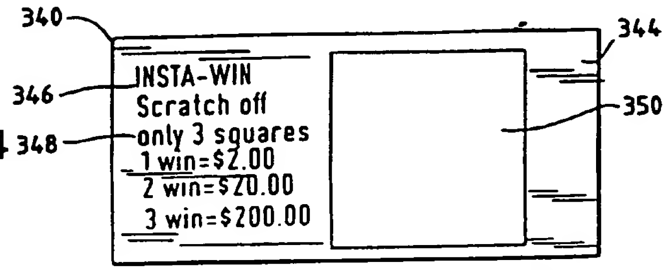


Fig. 25

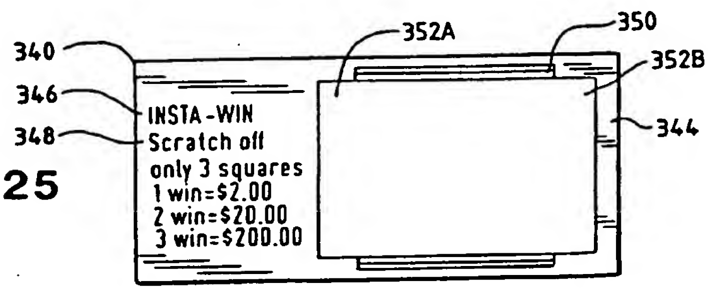


Fig. 26

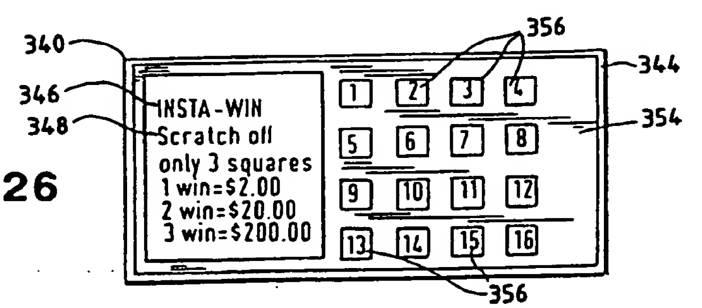


Fig. 27

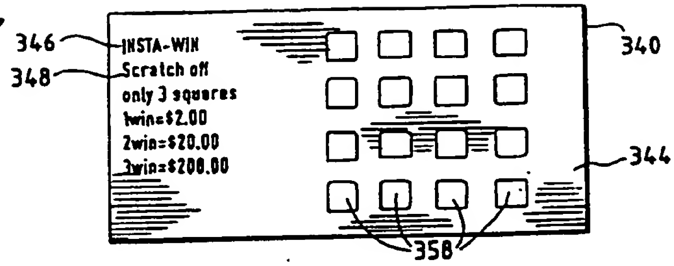
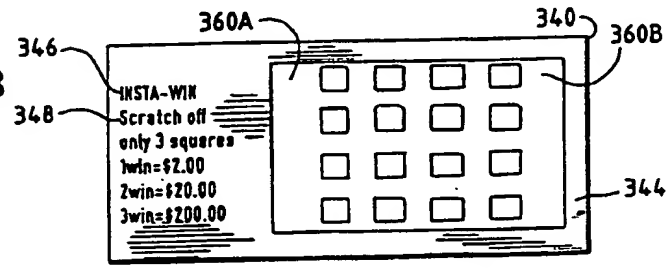


Fig. 28



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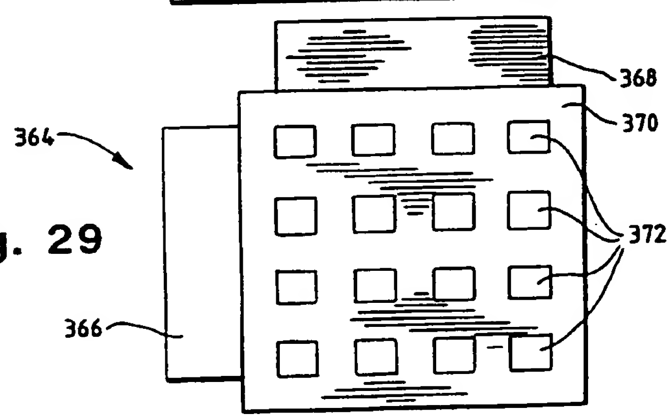


Fig. 30

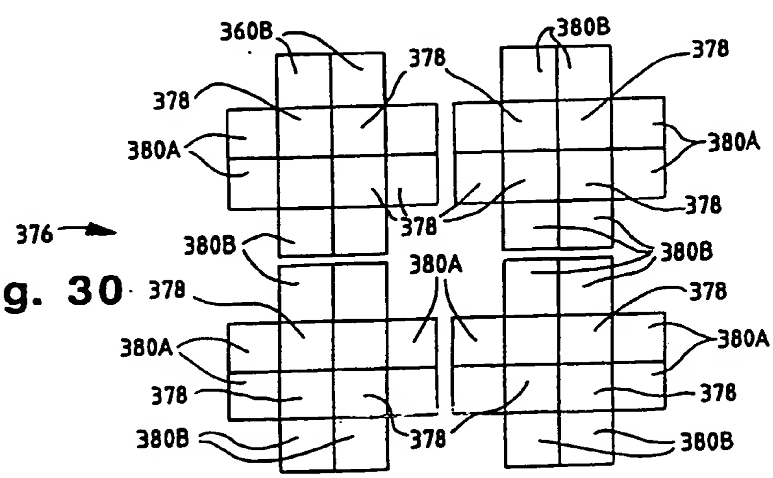


Fig. 31

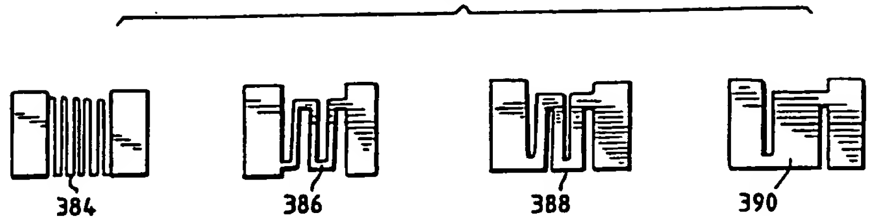
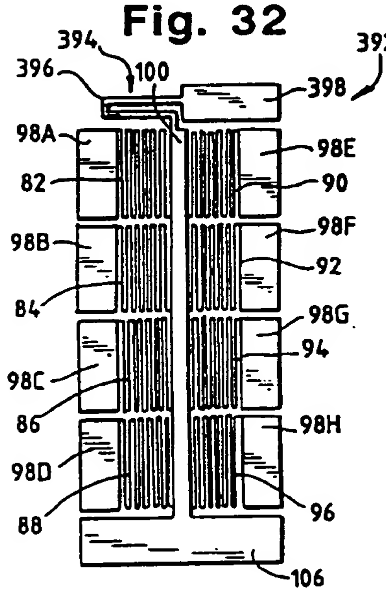


Fig. 32



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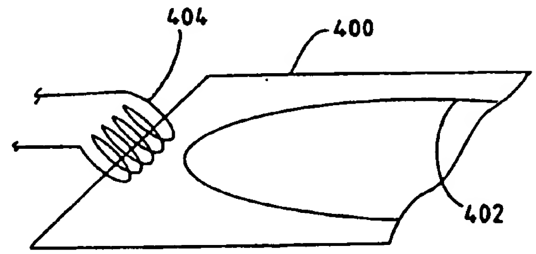

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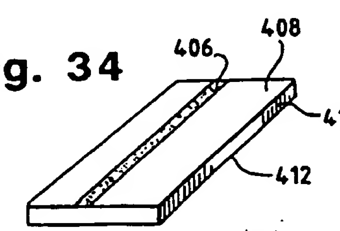


Fig. 35

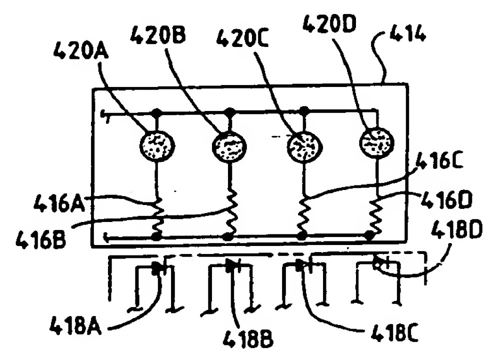
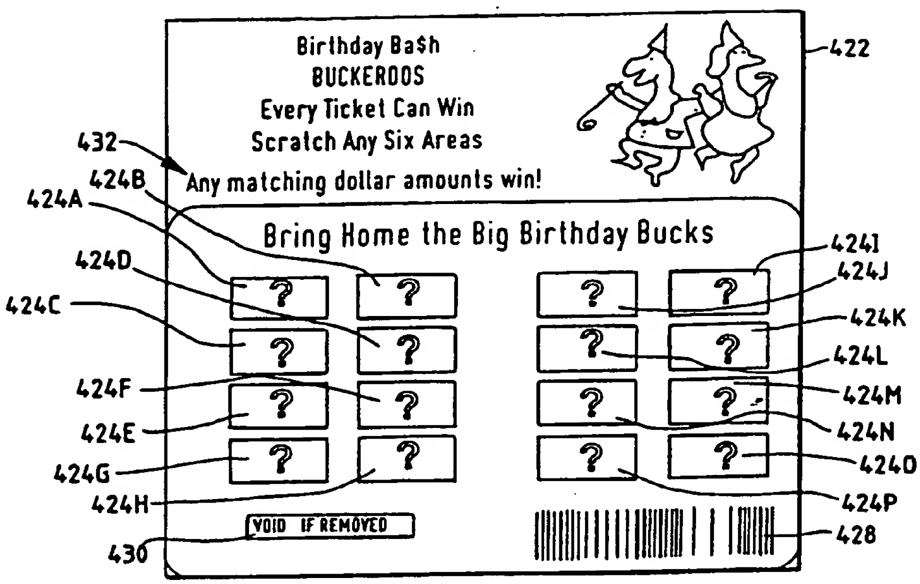
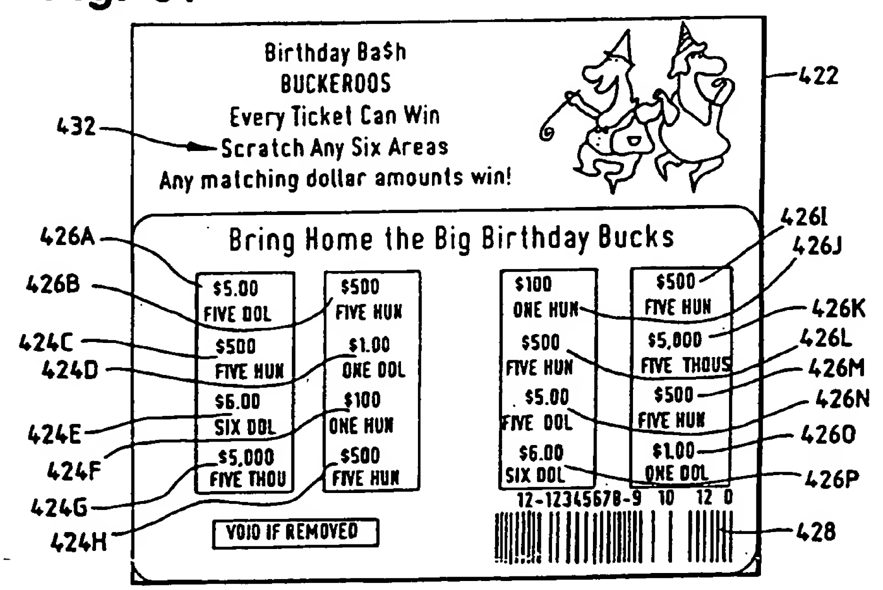


Fig. 36



Birthday Ba$h
BUCKEROOS
Every Ticket Can Win
Scratch Any Six Areas
Any matching dollar amounts win!
Bring Home the Big Birthday Bucks
VOID IF REMOVED
422
432
424A
424B
424C
424D
424E
424F
424G
424H
424I
424J
424K
424L
424M
424N
424O
424P
428
430

Fig. 37



Birthday Ba$h
BUCKEROOS
Every Ticket Can Win
Scratch Any Six Areas
Any matching dollar amounts win!
Bring Home the Big Birthday Bucks
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$6.00 SIX DOL
$5,000 FIVE THOU
$500 FIVE HUN
$1.00 ONE DOL
$100 ONE HUN
$500 FIVE HUN
$100 ONE HUN
$500 FIVE HUN
$5.00 FIVE DOL
$6.00 SIX DOL
$500 FIVE HUN
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$500 FIVE HUN
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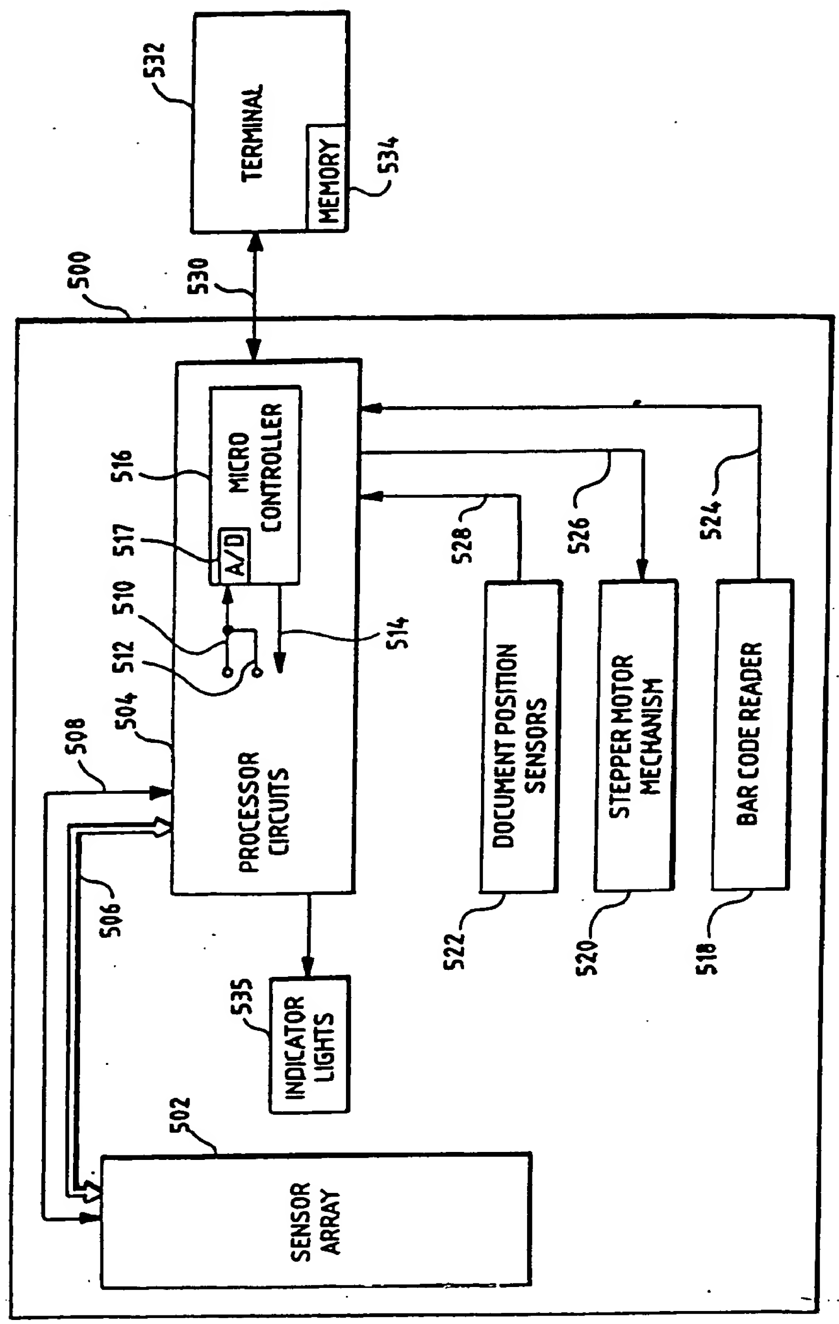
Fig. 38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PROCESSOR CIRCUITS
DOCUMENT POSITION SENSORS
STEPPER MOTOR MECHANISM
BAR CODE READER
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535
INDICATOR LIGHTS
502
SENSOR ARRAY

Fig. 39

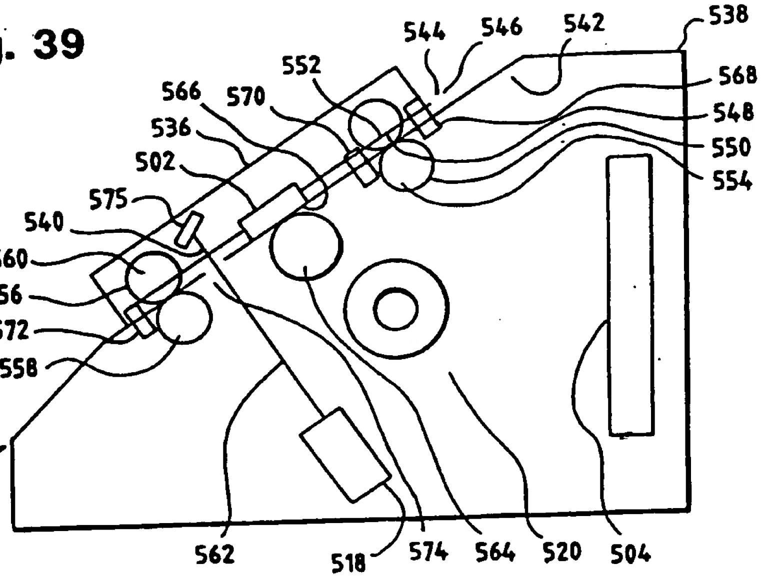
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Fig. 40

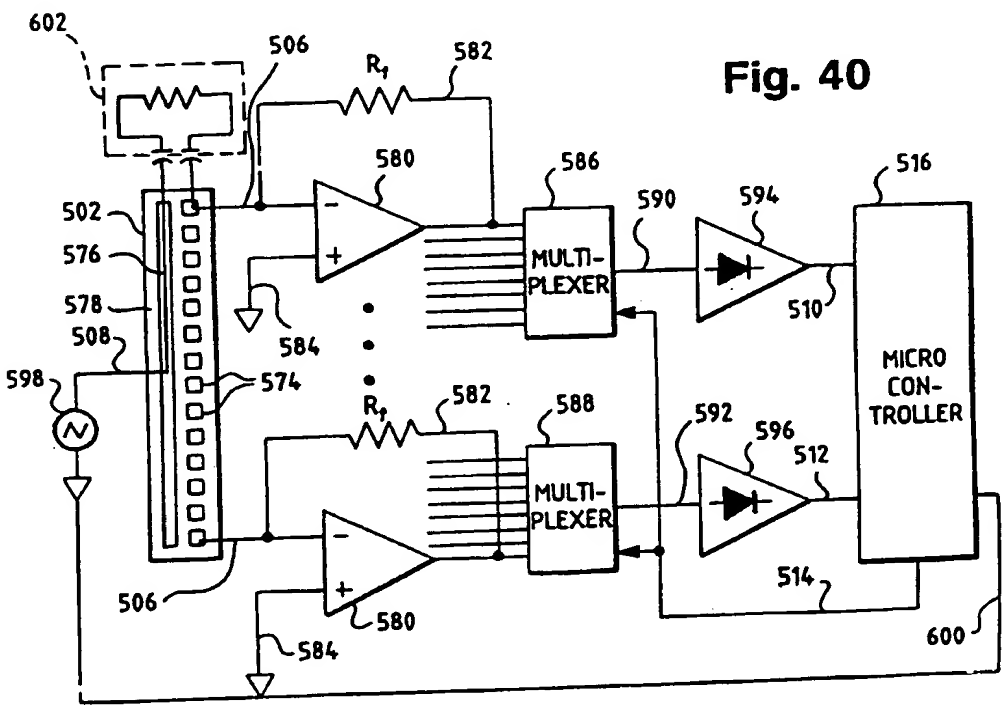
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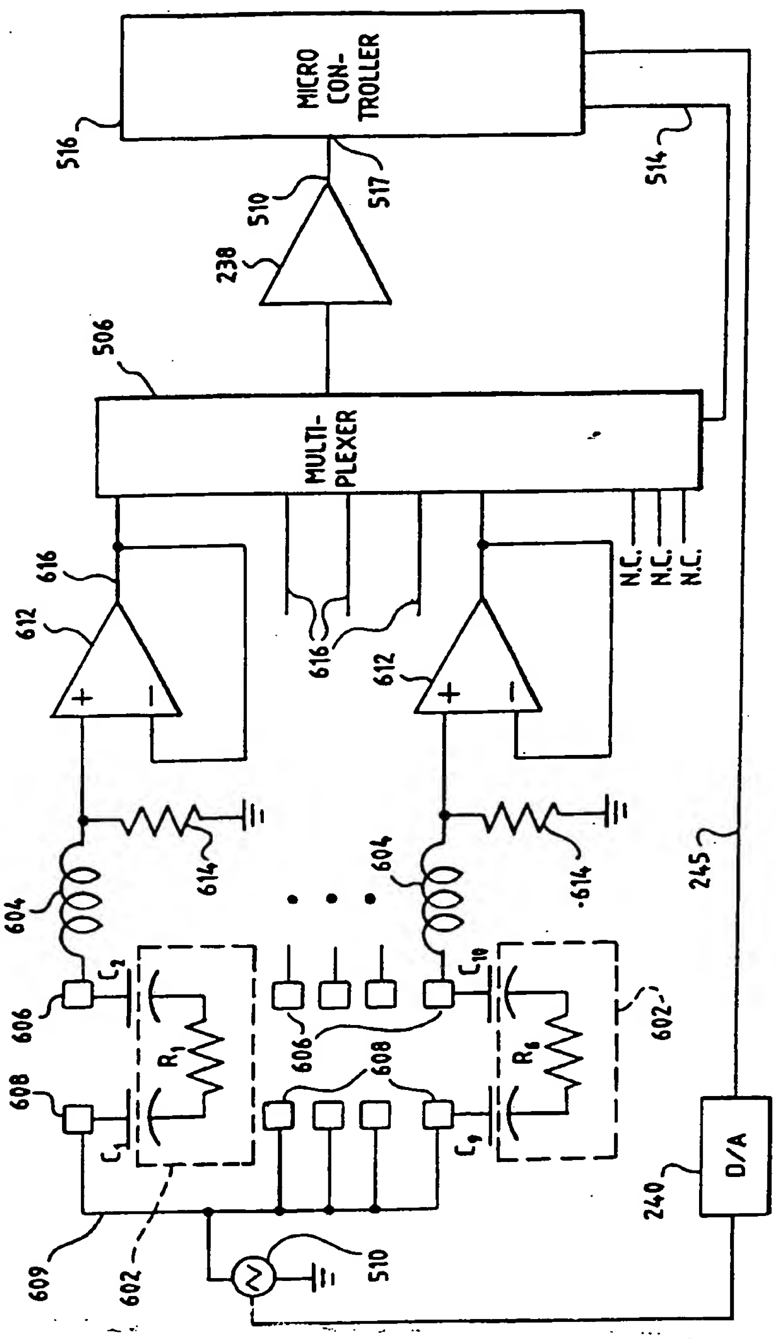
Fig. 41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C_2
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C_1
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Fig. 42

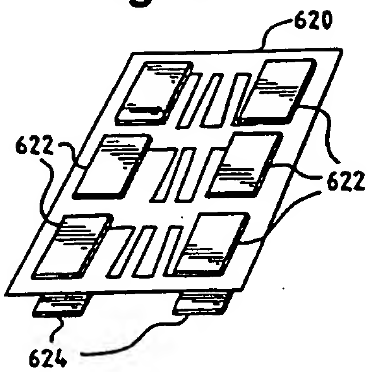


Fig. 43

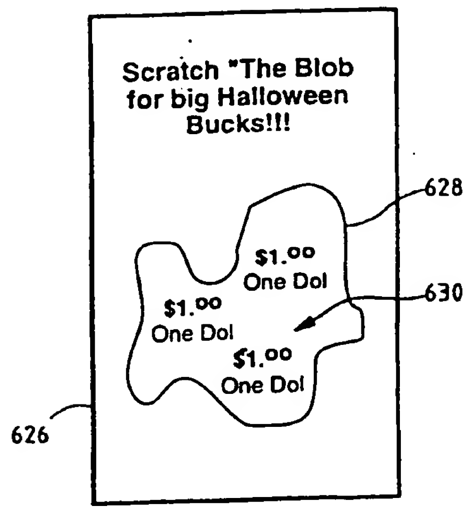


Fig. 44

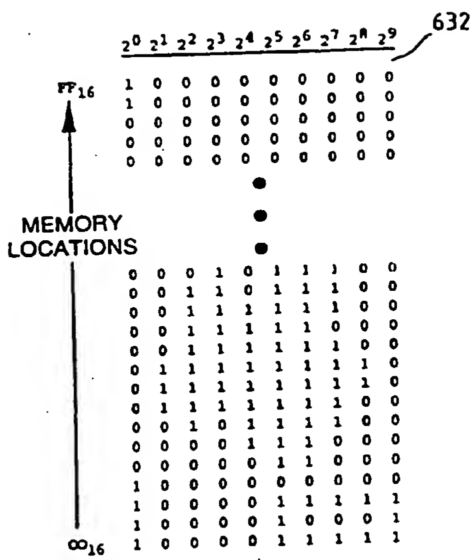


Fig. 45

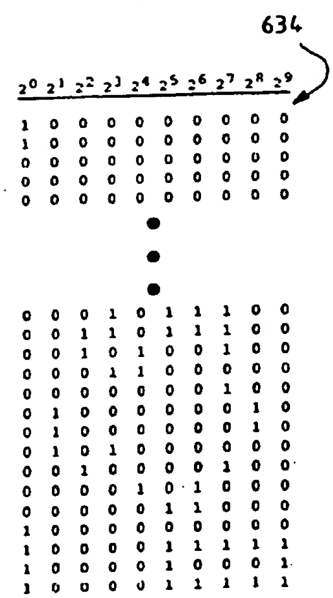


Fig. 46

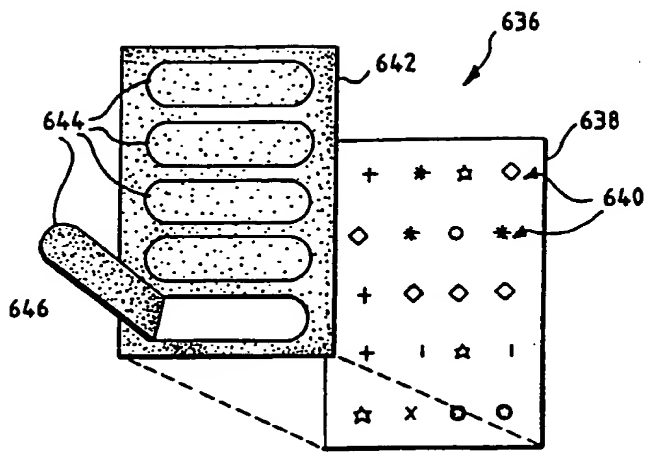


Fig. 47

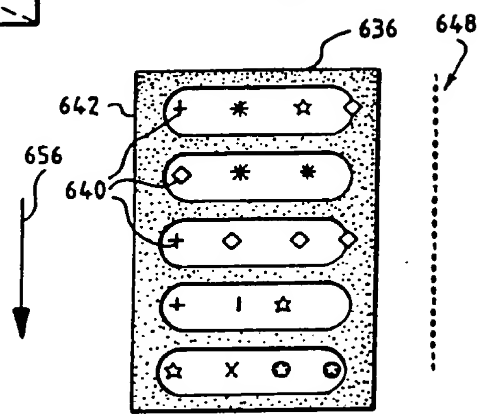
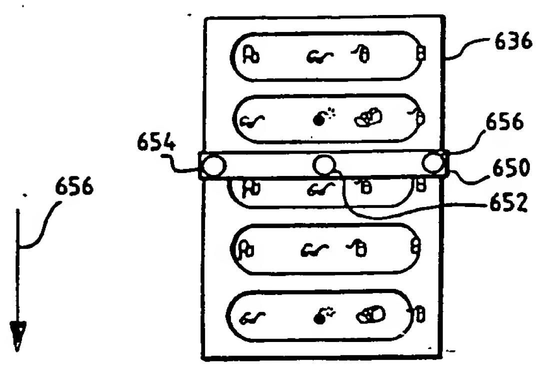


Fig. 48



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/08041

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G06F 15/20
US CL :235/375, 451, 441, 492, 440; 283/83, 102, 103, 903; 340/825.31, 825.34
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 235/375, 451, 441, 492, 440; 283/83, 102, 103, 903; 340/825.31, 825.34

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 3,699,311 (DUNBAR) 17 October 1972, whole document	1-119
A	US, A, 4,880,964 (DONAHUE) 14 November 1989, whole document	1-119
A	US, A, 5,151,582 (FUJIOKA) 29 September 1992, whole document	1-119
A	US, A, 5,346,258 (BEHM ET AL) 13 September 1994, whole document	1-119
Y,P	US, A, 5,475,205 (BEHM ET AL) 12 December 1995, whole document	1-119

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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Date of the actual completion of the international search
27 JUNE 1996

Date of mailing of the international search report
08 JUL 1996

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Authorized officer
MICHAEL G. LEE
Telephone No. (703) 305-3503

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/08041

B. FIELDS SEARCHED
Electronic data bases consulted (Name of data base and where practicable terms used):

APS
search terms: (document or substrate or paper or coupon or ticket) and (circuit or conductive ink), verif?(2w)machine, signal, excitation, detect?, plates, lottery, conductive material, printed, lottery and (ticket or coupon), conductive and (ink or material), array(p)sensors